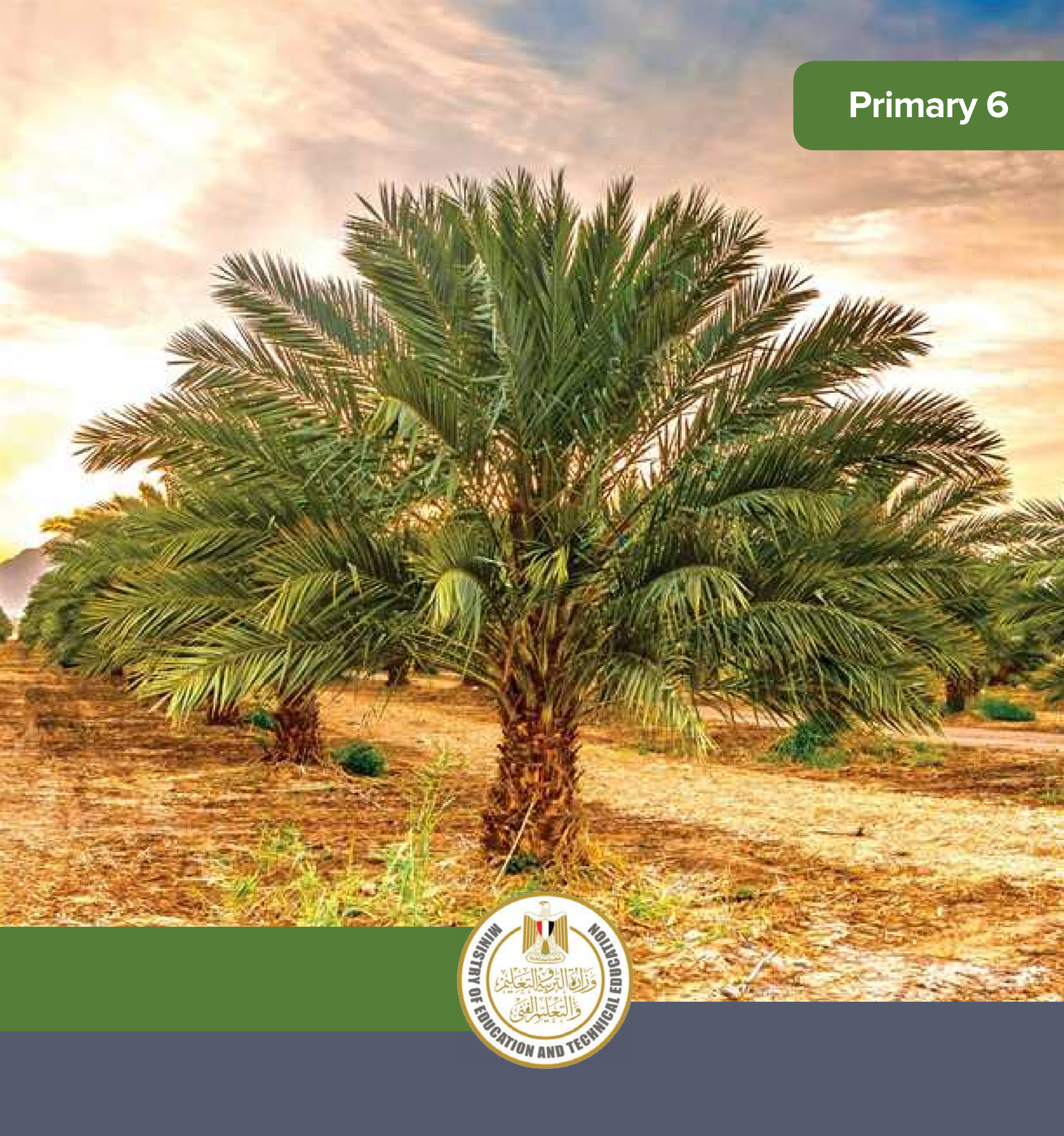
Primary 6



MINISTRY OF EDUCATION AND TECHNICAL EDUCATION

وزارة التربية والتعليم والتعليم الفني

Science Term 1

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WORDS FROM THE MINISTER OF EDUCATION & TECHNICAL EDUCATION

Dear students and fellow teachers,

It gives me great pleasure to celebrate this crucial stage of comprehensive and sustainable development, an epoch in which all Egyptian people are taking part. This pivotal stage necessitates paving a foundation for a strong educational system which yields a generation that is not only capable of facing the major challenges the world is witnessing today, but one that also has complete possession of the skills of the future.

At a time when our world is witnessing successive industrial revolutions, the Egyptian state is keen on empowering its citizens by establishing a top-notch educational system that invests in its children the expertise required to get them to compete at both a regional and global level. This dictates that our educational system has at its core an emphasis on skills development, deep understanding, and knowledge production. This can only be done through modern curricula that keep up with the changes taking place globally— curricula which prioritize the development of skills and values, and the integration of knowledge. They are also curricula that focus on the provision of multiple learning sources, and integration of technology to enrich the educational process and to improve its outcomes, while addressing the most important contemporary issues.

To achieve this, we must all join hands to continue to revolutionize our education, and to support it with all that is required to transform it into a globally pioneering educational system.

My warmest regards to you, dear students, and my deepest gratitude to my fellow teachers.

Professor Reda Hegazi

Minister of Education & Technical Education



Table of Contents

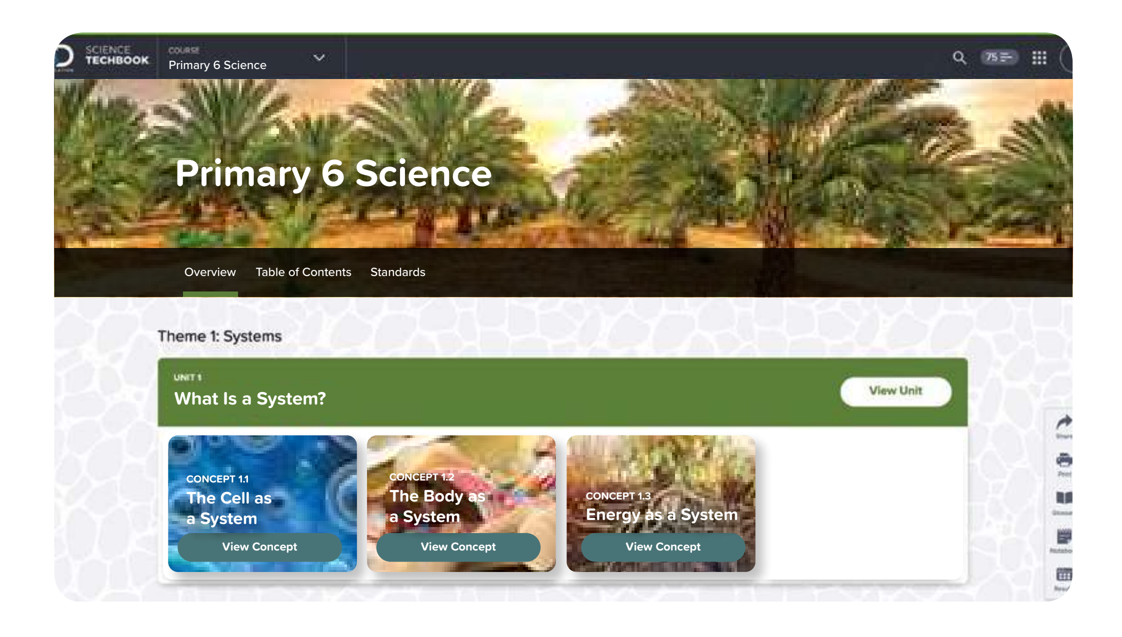
Unit Wrap-Up

Theme 2 | Matter and Energy

Unit 2: Getting Energy

Dear Parent/Guardian,

This year, your student will be using Science Techbook™, a comprehensive science program developed to inspire students to act and think like scientists and engineers. Throughout the year, students will ask questions about the world around them and solve real-world problems through the application of critical thinking across the domains of science (Life Science, Earth and Space Science, Physical Science, Environmental Science, and Engineering).



Science Techbook is an innovative program that helps your student master key scientific concepts. Students engage with interactive science materials to analyze and interpret data, think critically, solve problems, and make connections across science disciplines. Science Techbook includes dynamic content, videos, digital tools, hands-on investigations and labs, and game-like activities that inspire and motivate scientific learning and curiosity.

Science Techbook is divided into units, and each unit is divided into concepts. Each concept has three sections: Wonder, Learn, and Share.

Units and Concepts Students begin to consider the connections across fields of science to understand, analyze, and describe real-world phenomena.

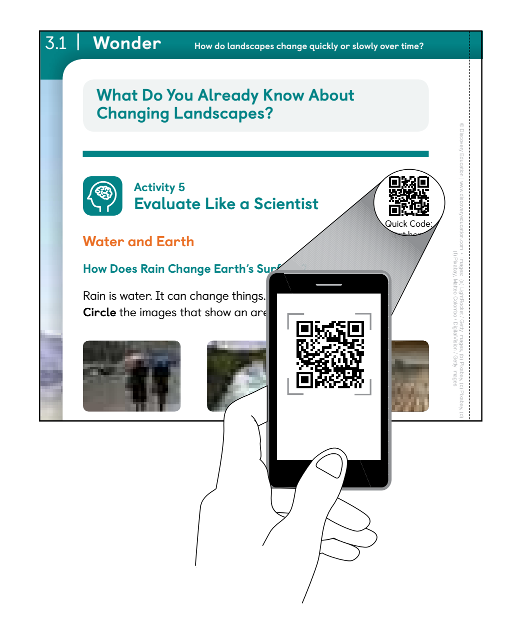
Wonder Students activate their curiosity and prior knowledge of a concept's essential ideas and begin making connections to a real-world situation.

Learn Students dive deeper into core scientific concepts through critical reading of texts and analysis of multimedia resources. Students also build their learning through investigations and interactives focused on the learning goals.

Share Students share what they are learning with their teacher and classmates using evidence they have gathered and analyzed during Learn. Students connect their learning with entrepreneurship, careers, and problem-solving skills.

Within this Student Edition, you will find QR codes and quick codes that take you and your student to a corresponding section of Science Techbook online.

We encourage you to support your student in using the print and online interactive materials in Science Techbook, on any device. Together, may you and your student enjoy a fantastic year of science and exploration.



Sincerely,

The Science Team



Theme 1 | Systems
Unit 1
What Is a System?
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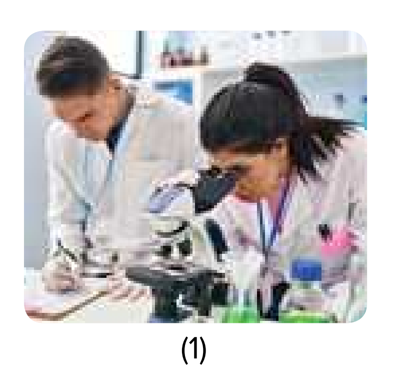
What I Already Know

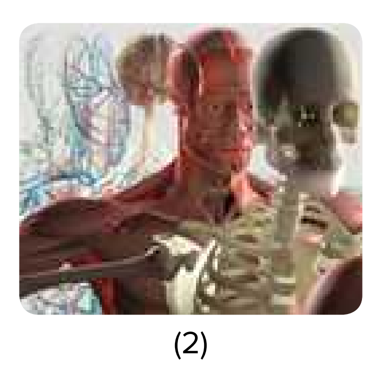

Quick Code: egs6001

What do you know about systems? A system could refer to a way that you do something. In science, we refer to systems of the human body based on their structure and function—for example, the digestive or muscular system. No matter what definition you use for system, it involves different parts working together in a specific way.

In this unit, you will learn more about the parts that work together to support human life. You will also learn more about how different physical parts, such as magnets or power sources, can be used to create a working electrical system, called a circuit.

As you look at the images that follow, consider how scientists gather information about the different parts of a system. In image 1, the scientist is using a microscope. Why might she need to use this device? In image 2, a scientific illustrator has created an image of different human body systems. How is it helpful to visualize the different body systems like this? In image 3, the door lock system shown uses a magnet. How have you seen magnets used? What other ways could you imagine magnets being used?


(1)


(2)

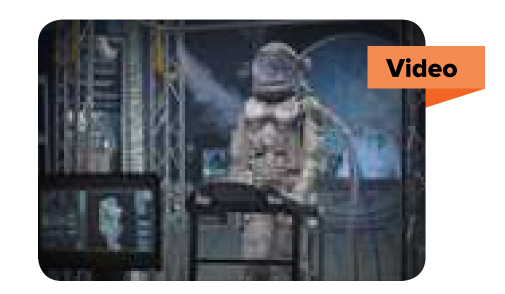

(3)

Observe the images and think about what you already know about systems. Also think about how scientists gather and visualize information about the different parts of a system. For example, **what tools can you use? How do scientific illustrations or diagrams help you understand the different parts of a system? How can you take your knowledge of different parts of a system and apply them to new situations or applications?**

Talk Together While one scientist is shown making observations using the microscope, the other is documenting findings. How can you work together with your classmates to make careful observations and also document your ideas as you begin your study of science this year?

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Astronaut Physical



Throughout this unit, you will explore how systems are made up of many parts working together to complete a common task. Interruptions to one part can affect how a whole system functions. The human body is one large system made of many small systems, the smallest of which is the cell. Astronauts who journey into space must cope with changing environmental conditions, which can be hard on the human body system. Therefore, before astronauts journey away from Earth, they must make sure that their bodies are functioning properly. Astronauts must train so that they are in peak physical condition before they leave Earth. They must also undergo rigorous physical examinations to qualify for travel.



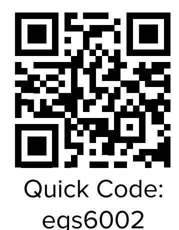
Astronaut Working on the International Space Station

Which environmental differences between Earth and space might be a problem for carrying out basic human body functions? Which bodily systems might be affected by space travel? What kinds of external devices and systems might astronauts rely on to keep them alive in space?

Life Skills **I can apply an idea in an innovative way.**



Solve Problems Like a Scientist



Quick Code: egs6002

Unit Project: Support System

In this activity, you will apply what you have learned about systems, both living and nonliving, to space travel and the human body. You will design a product that could help solve a health-related problem that astronauts face.



International Space Station

Ask Questions About the Problem

Think about the difference between the environment here on Earth and in the rest of the solar system. You know how much gravity impacts our everyday life. Imagine you are an astronaut living in an environment of microgravity. You can float around the space station as if you are swimming underwater. What impact would this have on your body systems? Would your muscles and organs function in the same way as they do here on Earth? What types of devices would help your body adjust and function within this type of environment? As you learn about how your cells and organs work to support your body systems and how electricity can be used to power a system, record the answers to your questions.

Can you design an external support system that could help astronauts combat the effects of space travel on their human body system?

Life Skills **I can identify problems and plan solutions.**

CONCEPT 1.1

The Cell as a System

Student Objectives

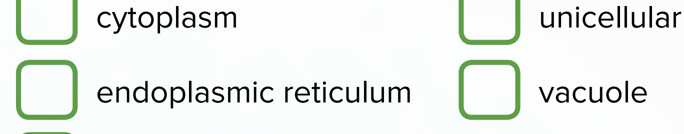
By the end of this concept:

- [ ] I can investigate and collect evidence that supports the idea that living things are made of cells.
- [ ] I can develop a model to describe the function of a cell as a whole and how the parts contribute to the overall function.
- [ ] I can argue from evidence that living things are made up of either one cell or many different numbers and types of cells.
- [ ] I can compare animal cells and plant cells.

Photo Credit: Paulista / Shutterstock.com

Key Vocabulary

- [ ] bacteria
- [ ] cell
- [ ] cell membrane
- [ ] cell wall
- [ ] chloroplast
- [ ] cytoplasm
- [ ] endoplasmic reticulum
- [ ] Golgi apparatus
- [ ] mitochondria
- [ ] multicellular
- [ ] nucleus
- [ ] organ
- [ ] plasma membrane
- [ ] unicellular
- [ ] vacuole





Quick Code: egs6004

Activity 1

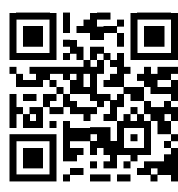
Can You Explain?
The Cell as a System





In this unit, you will focus on systems in our world. The first system we will consider is the **cell**. Think about what you already know about cells. Where are cells found? How big is a cell? Are cells found in all things?

What is a cell?

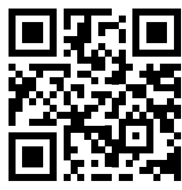


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egs6007

Photo Credit: (a) Paulista / Shutterstock.com, (b) UGREEN 3S / Shutterstock.com

Activity 2

Ask Questions Like a Scientist



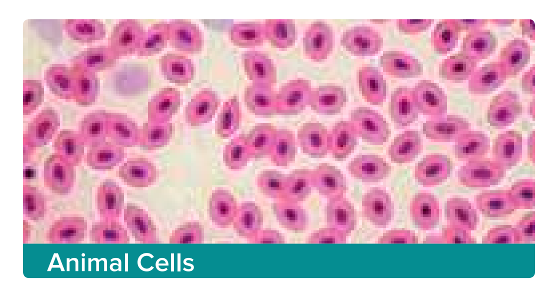
Quick Code: egs6008

Building Blocks of Living Organisms

Have you ever seen a cell? What do you think a cell looks like? Why are cells important? Read the text. Think about questions you might have about cells as building blocks of living organism.



Plant Cells



Animal Cells

Building Blocks of Living Organisms

Cells as Building Blocks

Organisms can look very different from each other. All living things have one thing in common: each is made of one or more cells. These cells are the basic units, or building blocks, of life on Earth. Just as toy building blocks can be used to create many different structures, from play cars to castles, cells are units that form many different living things.

Cells Are Usually Very Small

Most cells are very small. The unaided human eye can see objects that are about 0.1 millimeters (mm) long. This means that while you may be able to see some large cells, to see smaller cells you will need a microscope. Common plant and animal cells are between 0.1 and 0.005 mm long. The cells of **bacteria** are usually smaller than this. Some cells are very large. An unfertilized bird egg contains only one egg cell.

Think about what you have read and what you already know about cells. Record questions you would like answered as you learn about cells in this unit. **Write three questions you have and share them with the class.**

I wonder . . .

Once you have recorded your Wonder statements, share them with a partner. **Feel free to add any new questions that come up in your discussion to your list.**



Activity 3

Evaluate Like a Scientist



Quick Code:
egs6009

What Do You Already Know About the Cell as a System?

Organism Growth and Cells

Living organisms grow and reproduce.

Since they are all formed of cells, how do you think organisms grow by increasing?

A. the size of their cells

B. the number of cells

C. equally the size and number of cells

Characteristics of Cells

Read the statements about cells and classify each as either true or false.

All cells have a nucleus.

All cells in an organism are identical.

All cells have a cell wall.

All cells have a cell membrane.

All living organisms are composed of more than one cell.

True	False

Life Skills **I can determine if a source is credible.**



Activity 4

Analyze Like a Scientist

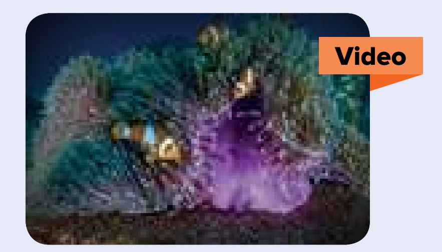


Quick Code:
egs6010

Cell Needs

You have been thinking about cells and their function. Read the text and watch the video. As you read, underline the needs of cells. Be ready to discuss what you have read.

The cell is a complex structure that carries out all its own life activities. Cells are the building blocks of all living things. All living organisms, including you, are made of cells. All new cells come from existing cells.



Most cells are so small they cannot be seen without a microscope. Although they are very small, cells are what keep us alive. The basic needs of a cell should seem familiar to you as you consider the needs of all living organisms. To grow and live, cells need energy in the form of food and oxygen. Cells must have a way of taking in needed materials, using them to get energy, and releasing waste products.

Water is also necessary for life. All cells allow water to pass through a **cell membrane** and into the cell. If too much water enters the cell, however, the cell will swell until it bursts. To prevent this from happening, water is also allowed to leave the cell. In this way, cells are able to maintain the proper water balance on both sides of the cell membrane.



Talk Together How are the needs of cells similar to and different from the needs of a complex living organism, such as a plant, animal, or human?



Activity 5

Observe Like a Scientist





Quick Code: egs6012

Brief History of the Cell

Watch the video and read the text. Think about why it is important to share research.



In 1665, Robert Hooke used the newly invented microscope to observe things too small to be seen by the unaided eye. Hooke looked at samples and described little sections in the sample. Hooke was the first person to use the word *cell* to describe these tiny images.

Improved microscopes have allowed scientists to make new discoveries. For example, the **nucleus** of a cell was discovered through observation of numerous plant cells. Later, scientists determined that cells are the basic unit of structure in living things. Sometimes a single cell exists on its own, but more complex systems include many cells. All living things are made of cells, no matter how big or small the living thing is. As better microscopes have been developed, scientists have been able to look at small things in more detail. Scientists can use information learned from one another's research to better understand cells today.

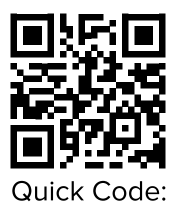
- **Why is it important for researchers to trust the intellectual honesty of the work of others as they learn about cells?**
- **Why must scientists be open to new ideas about how cells work?**

Life Skills **I can reflect on the contribution of individuals to the group.**



Activity 6

Investigate Like a Scientist



Quick Code:
egs6013

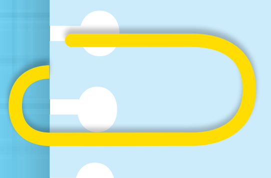
Hands-On Investigation: Using a Microscope to View Cells

Today, you will observe a demonstration of how to use a microscope. Be sure to take notes so you will be able to use a microscope in further investigations. You will also make observations and draw what you view in the microscope.

Make a Prediction

Notice the slide in your teacher's hand for the cell, and think about what you can see under the microscope. What do you expect to observe when looking at the slide under the microscope?

What do you expect to observe when looking at the pepper skin under the a microscope?



What materials will be used? (per group)

- Thin slice of the skin of a green pepper
- Eyedropper
- Water
- Compound microscope
- Microscope slide
- Coverslip
- Forceps
- Different aquatic plant leaves (optional)
- Thin membrane from an onion (optional)
- Prepared slide of animal cell (optional)
- Slide of animal cell



What Will You Do?

Record the steps your teacher uses to prepare a microscope slide.

Think About the Activity

Use the diagram to help you describe the parts of a microscope with the proper terms.

Microscope Parts

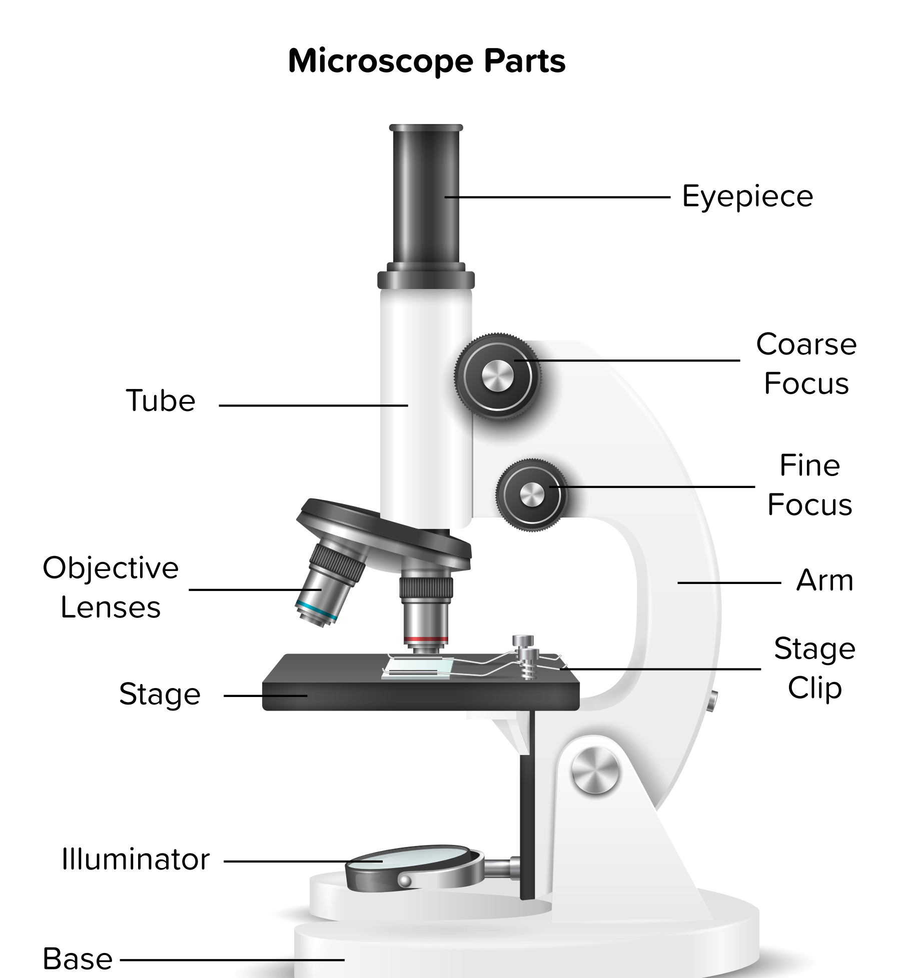


Photo Credit: gomolach / Shutterstock.com

- **Record the steps for operating a microscope.**
- **Draw the images you saw.**



Activity 7

Observe Like a Scientist

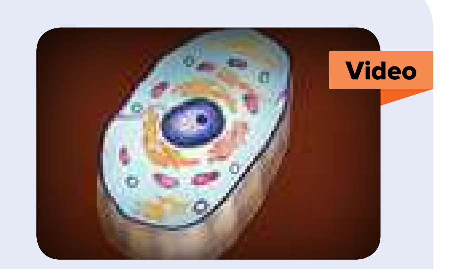




Quick Code:
egs6015

The Parts of a Cell

As you watch the video and read the text, consider the following questions:
How can living organisms vary in complexity from one another?
What makes a cell a system? Be prepared to discuss your responses using evidence and reasoning.



All living organisms are made of one or more cells. Organisms made up of only one cell are called **unicellular**. Living organisms with more than one cell are **multicellular**. The cells that make up complex organisms, such as plants and animals, have a nucleus at the center. The nucleus functions as a control center for the organelles. An organelle is a structure within the cell that has a special function.

The structure of most multicellular organisms is organized into five levels: cell, tissue, **organ**, organ system, and entire organism. The number of cells in plants and animals varies from species to species. Humans have about 40 trillion cells. Each cell is surrounded by a **plasma membrane** that protects the cell and regulates what can enter. **Cytoplasm** is inside the membrane and supports the organelles.

Each plant cell has a **cell wall** made of cellulose. Specialized types of plant cells perform photosynthesis or collect water and mineral nutrients. Animals have a variety of cell types, including muscle cells, bone cells, and blood cells.

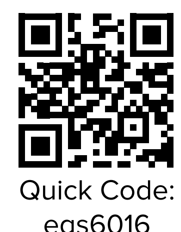
Similar cells within organisms that share a common origin and perform the same function are often grouped together to form a tissue. An organ is a group of tissues joined together and involved in performing a particular function. Each level of biological organization plays a specific role related to that organism's structure and function.

- **How can living organisms vary in complexity from one another?**
- **What are the systems that keep multicellular organisms alive?**
- **What makes a cell a system?**



Activity 8

Analyze Like a Scientist



Quick Code:
egs6016

The Functions of Cell Parts

Read the passage. Then, label the diagram of a cell with the parts you learned about in the reading passage.

The Functions of Cell Parts

Different cells have different structures. In particular, the cells of multicellular organisms can vary greatly.



Cells



Blood Cells Under Microscope

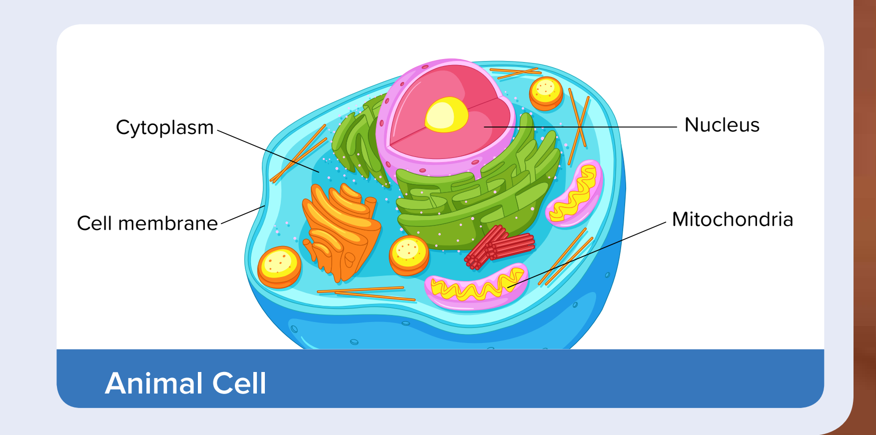
Common characteristics

Despite these differences, most cells share some common characteristics. Most cells have cytoplasm, a cell membrane, a nucleus, and **mitochondria**. Cytoplasm is the gelatinous liquid inside of cells in which other cell parts float. The cell membrane is the outer lining of the cell. It helps control which substances can enter or leave the cell. The cell membrane is said to be “selectively permeable.” This is because some substances can pass through it, while others cannot.

The mitochondria are the powerhouses of the cell, as they supply the cell with the energy it needs. Cellular respiration takes place in the mitochondria. Cellular respiration is the process of using oxygen to obtain chemical energy from food so that cells can continue to function.

The Nucleus

The cell nucleus is responsible for controlling cellular activities. These activities include making proteins and dividing to make new cells.



Animal Cell

Label the diagram.

Not all parts will be labeled.

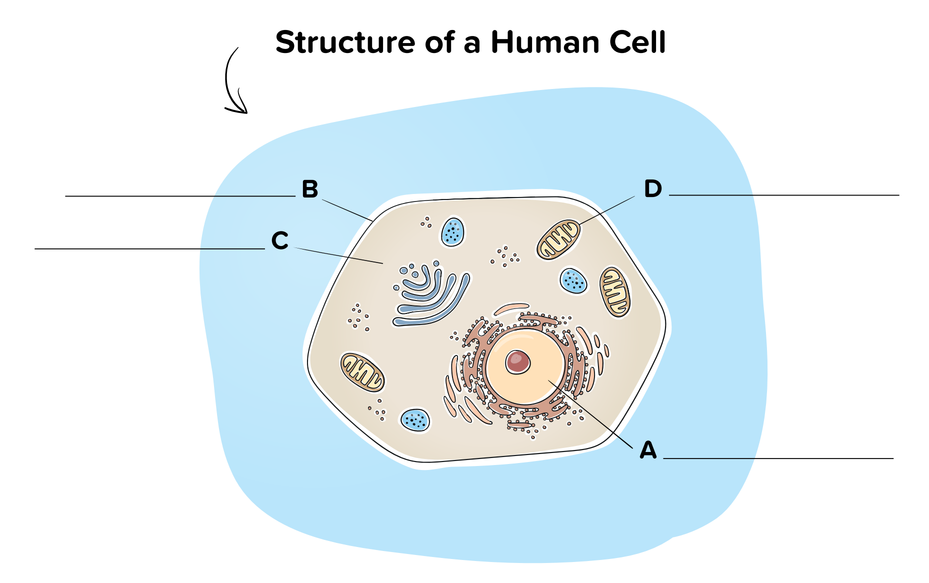


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Activity 9

Analyze Like a Scientist





Quick Code: egs6018

Comparing Plant and Animal Cells

Read the passage. Look at the image. What cells are in the image? How does a plant cell differ from an animal cell?

Comparing Plant and Animal Cells

One of the main differences between plants and animals is usually obvious. Most plants are green. But the evidence for where this green coloring comes from is so tiny that you need a microscope to really see it. If you look at a plant cell under a microscope, you can see that it has tiny green granules. These granules are green because they contain the pigment chlorophyll. This pigment absorbs energy from sunlight. The energy is then used in an organelle called a **chloroplast** to make food for the plant. Animal cells do not have chloroplasts or cell walls.



Cell Models

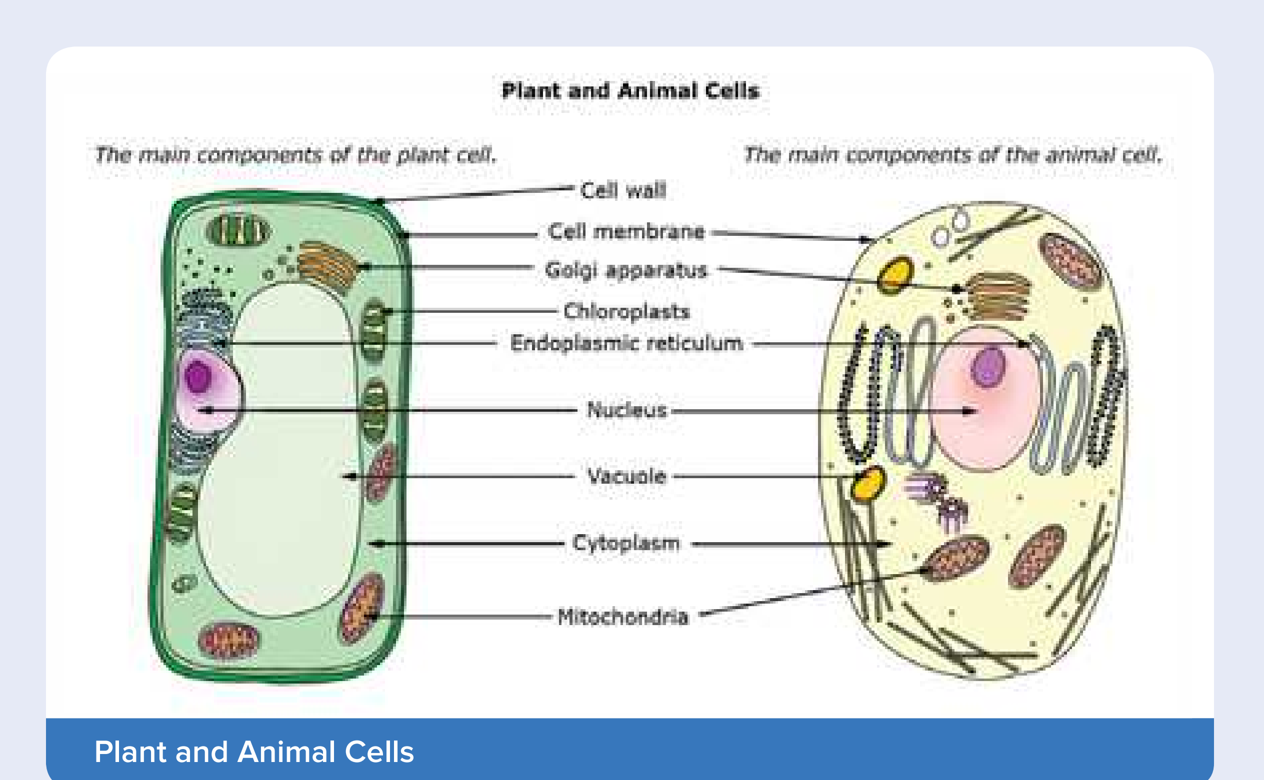
While animals cannot make their own food, do you know why? This is reflected in the fact that they do not have chloroplasts in their cells.

Cell Walls

Animal cells do not have a cell wall because animals do not take on the rigid structures that plants do. Animals have other structures help to keep their shape. Some animals have bones. Other animals, such as insects, have a hard, shell-like covering called an exoskeleton that gives them shape. Look at the chart to see the similar and different organelles that are present in plant and animal cells.

Common Cell Organelles

Overall, plant and animal cells have many organelles in common. Both plant and animal cells have organelles to help control, organize, and maintain the cell. These are functions that are mainly done by the cell nucleus, **endoplasmic reticulum**, cell membrane, cytoplasm, and mitochondria. Both plant and animal cells have **Golgi apparatus**. This organelle helps package and transport cellular materials. So, even though plants and animals are very different organisms, they have some very similar structures within their cells.



Plant and Animal Cells

Photo Credit: Vladra14 / Shutterstock.com



Comparing Plant and Animal Cells, *continued*

Organelle	Function	Illustration
Mitochondria	Converts sugar into energy for the cell	
Cell nucleus	Controls the functions inside the cell and cell division	
Endoplasmic reticulum	Helps in assembling and transporting proteins	
Golgi apparatus	Helps preparing , package and transport materials within the cells and transported them out of the cell	
Cell membrane	The surrounding layer of the cell that controls what materials enter and leave the cell	

Organelle	Function	Illustration
Cytoplasm	The liquid inside the cell that surrounds the organelles	
Vacuole	Saclike structures used for storage of nutrients, water, and waste; in plant cells, large vacuoles contain water	
Chloroplast	Contains chlorophyll and carries out photosynthesis; only found in plants	
Cell wall	The rigid outside material that surrounds plant cells to give them a definite shape; only found in plants	

You know that plant and animal cells have similarities and differences. Use the text and the chart to answer the following questions:

- **Which organelles are present in plant cells that are not present in animal cells?**
- **What is the structure and function of the organelles that are only present in plants?**
- **Why do you think plant and animal cells have many of the same organelles?**



Activity 10

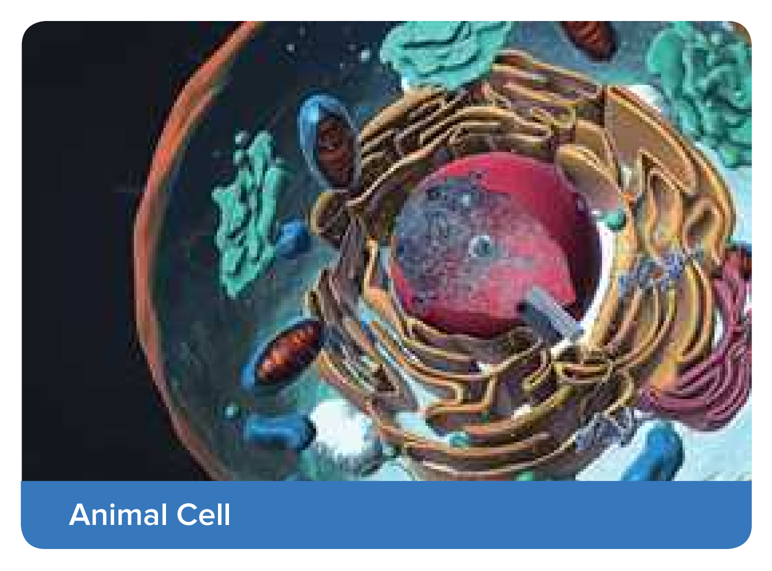
Evaluate Like a Scientist



Quick Code:
egs6019

Project: Planning a Cell City

Structures within cells are specialized for specific functions. One analogy for a cell is structures within a city, which are specialized to carry out needed functions of the city. In what ways can a city be considered a model of a cell?



Animal Cell

Suppose you are an engineer, and you have been asked to design a cell city model to display in a local science museum. In this activity, you will brainstorm city structures that could represent different organelles. You will also plan what materials you could use to model each component. Finally, you will create a drawing of your plan to be used as a blueprint for building an actual model in the following activity:

Life Skills **I can apply an idea in an innovative way.**

Cell City

The following table shows some of the common organelles that you learned about in previous activities. The first three have been matched with a possible city structure that could represent the function of different parts of a cell. Talk with your classmates to brainstorm city structures that could model the function of each of the remaining organelles.

Cell Structures	City Structures
Nucleus	City hall
Cell membrane	Guards at city gates
Mitochondrion	Electrical power station
Endoplasmic reticulum	
Golgi apparatus	
Vacuole	
Cell wall (plants only)	
Chloroplast (plants only)	

Model Materials

Write a list of materials you would need to build your model. Try to choose everyday materials that would be easy to gather or find at home or school.

Plan and Design Your Model

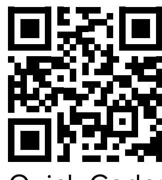
Once your list is approved by your teacher, create a plan for a 3D model of your cell city. Include labels for each organelle to explain what city structure the organelle represents and why.



Activity 11

Investigate Like a Scientist





Quick Code:
egs6021

Hands-On Investigation: Build a Cell City

In this investigation, you will use the plans for building a cell city that you developed in the previous activity to create a visual model of a cell. You will present your model and observe the models built by other groups.

Make a Prediction

Consider what you already know about the differences between plant and animal cells.

How do you predict the models of plant and animal cells will vary? Are there any structures you will only find in one type of model?

What Will You Do?

1. With your group, review your plans for building a cell city that you created in the previous activity.
2. Gather your materials and work together to build your model.
3. Label each structure. Include both the name of the organelle being represented and the city structure.
4. Plan a presentation with your group. You should include both process (how you worked together) and your product (the model and its components).
5. When directed by your teacher, participate in a Gallery Walk to view other groups' models.

What materials do you need? (per group)

- Plans for building a cell city (from previous activity)
- Modeling supplies, including clay and recyclable materials
- Art supplies, including paint and markers
- Other materials as specified in previous activity



Think About the Activity

- **What differences did you notice between the models built by your class?**
- **How does building a model help you understand the cell as a system?**



Activity 12

Record Evidence Like a Scientist





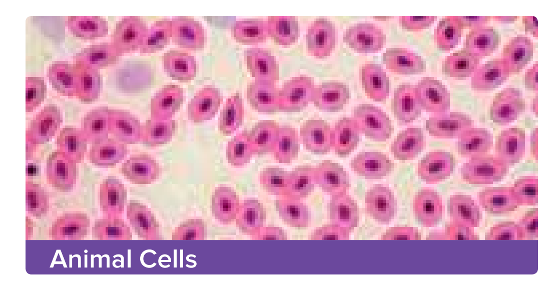
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Circle Back: The Cell as a System

Now that you have learned about the cell as a system, look again at Building Blocks of Living Organisms. You first saw this in Wonder.



Plant Cells



Animal Cells

How can you describe Building Blocks of Living Organisms now?

How is your explanation different from before?

Look at the Can You Explain? question. You first read this question at the beginning of the concept.



Can You Explain?

What is a cell?

Now you will use your new ideas about Building Blocks of Living Organisms to defend a claim using evidence. First, write your claim. A claim is a one-sentence answer to the question you investigated. It answers, What can you conclude? It should not start with *yes* or *no*.

Record your claim.

Next, **record the evidence that supports your claim.** Evidence can come from videos, readings, interactives, and Hands-On Investigations.

Record your evidence-based scientific explanation.

Choose one additional idea that you would like to research.
What would you do to learn more? What resources would you use to extend your research? How would you build upon your investigations?

Record your research, and the resources you used.

Life Skills **I can apply an idea in an innovative way.**

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Quick Code:
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Activity 13

Analyze Like a Scientist

Careers and Cell Biology

You have learned a lot about cells in this concept. What does it mean to be a cell biologist? How do scientists see deep within a cell? Read the text and then discuss your ideas.

Cell Staining and 3D Cell Microscopes

Cells are very tiny. The typical animal cell measures about 10 microns, or 0.001 centimeters, in diameter. Their internal structures are even smaller. Cell biologists are scientists who study cells. They study how cells function in the living organisms that they make up. Most cell biologists work in laboratories. They design and conduct experiments and often investigate how cells respond to different variables. Cell biologists analyze data and present their findings to other researchers. Some cell scientists work with doctors to watch how cells can work to repair body parts or how cells respond to medication. Others work in agriculture, studying how plant cells respond to different environmental factors. To do research and study cells, these scientists must use microscopes. Compound microscopes magnify cells so they seem larger.



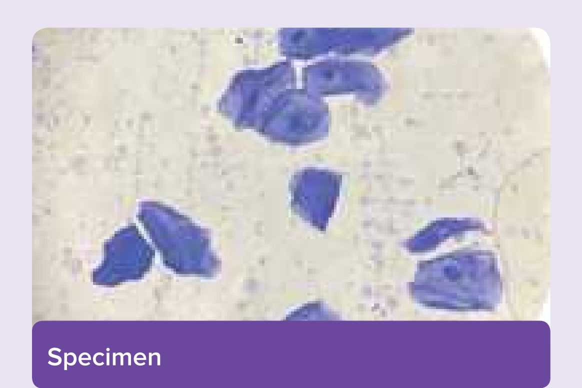
Cell Biologist

Photo Credit: Kzenon / Shutterstock.com


Preparing a Specimen

Staining Cells

Cells are usually clear and colorless. It is hard to see their structures, even when viewed under a microscope. Stains are used to add color and make the cell's structures more visible. Different stains are chosen for different types of cells. Some stains highlight specific areas of the cell. One type of dye, methylene blue, specializes in making one part of cells more visible. As you look at the image of cheek lining membrane cells (taken from inside the mouth), notice the blue stain that helps you better see the nucleus.


Specimen

Cells in 3D

Scientists have developed a better way to see cells. Scientists have built a microscope that shows a live cell in 3D. This means scientists can see the top, sides, and layers of a cell. How does the microscope do that? These new 3D microscopes take pictures of the cell in layers. A computer puts the layers together. Color is then added to the image.

This technology can help biologists learn more about cell parts and how cells divide. This may help doctors who treat cancer, which is caused by cells that divide too quickly. These doctors can then offer more help to patients who have cancer.

Unit Project Connections: The Cell as a System

How does what you have learned about the function of different cell parts and the cell as a system connect to the Unit Project, Support System? What research and resources will you need to complete the Unit Project?

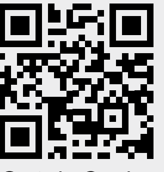

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CONCEPT 1.2

The Body as a System

Student Objectives

By the end of this concept:

- [ ] I can create a model to demonstrate understanding of the relationship between cells, tissues, organs, and systems.
- [ ] I can collect evidence that shows that the excretory system is an example of the coordination among multiple body systems.
- [ ] I can describe interactions among body systems to explain how they contribute to the overall function of the body.
- [ ] I can argue from evidence that the body is a system of interacting subsystems composed of groups of cells that form tissues and organs.

Key Vocabulary

- [ ] bladder
- [ ] circulatory system
- [ ] contract
- [ ] digestion
- [ ] endocrine system
- [ ] excretory system
- [ ] gallbladder
- [ ] glands
- [ ] kidney
- [ ] lungs
- [ ] muscle
- [ ] musculoskeletal system
- [ ] nephron
- [ ] pancreas
- [ ] tissues
- [ ] urethra
- [ ] urinary system

Quick Code:
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Photo Credit: MikhailSh / Shutterstock.com

Activity 1

Can You Explain?
The Body as a System

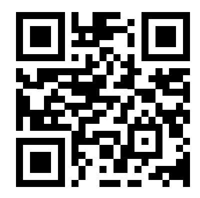




Think about a time when you were nervous about something. Maybe you were nervous about taking a test or presenting in front of the class. What happened within your body when you were nervous?

Now that you have thought about your body's reaction, think about how your body works as a system. How do organ systems work together as one whole body system? Record your answers.

How does my body function as a system?



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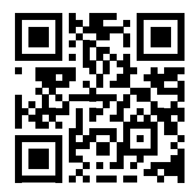
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Activity 2

Ask Questions Like a Scientist



Quick Code:
egs6031

Danger Response

You know that organs, such as your heart and lungs, work to keep your body functioning. But how do individual organ systems work together to keep your body functioning as one whole system?

Look at the image of the cyclist. The cyclist is in a dangerous situation. Imagine how you would feel if this were you. Now think about how body systems work together to produce physical responses, such as an increase in heart rate. Consider why interactions between systems are important in dangerous situations.



Freestyle Cyclist image

How do your body systems work together in dangerous situations? Think about how your body works as a system.

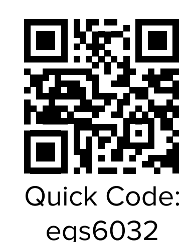
Write three questions you have and share them with the class.



Once you have recorded your Wonder statements, share them with a partner. Add any new questions that come up in your discussion to the list.



Activity 3
Evaluate Like a Scientist



Quick Code:
egs6032

What Do You Already Know About the Body as a System?

You learned previously about some body systems and how they interact with other body systems. Let's review what you already know.

Body Systems

The nervous system is one system among several in the human body.
To function, does the nervous system depend on other systems, such as the circulatory system or the digestive system? Do these systems depend on the nervous system? Explain your reasoning and give examples for each answer.

Arm Movement

The movement of an arm to pick up a glass of water requires many events.
Use the words from the word bank to complete each sentence in the paragraph.

arm	brain	eyes	heart

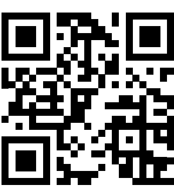
To pick up a glass of water, the ____________________ first see the location of the glass on the table. The ____________________ then coordinates the needed movement and sends instructions to muscles. the ____________________ pumps more blood to feed the muscles required for movement. Muscles in the ____________________ then contract to move toward the water.



Activity 4

Analyze Like a Scientist





Quick Code:
egs6034

Building Living Systems

Previously, you learned about how cells are the building blocks of all living organisms. How can something so small create a much larger organism? How are cells organized to build the human body? As you read, look for the different ways that small parts of the human body are organized into larger systems.

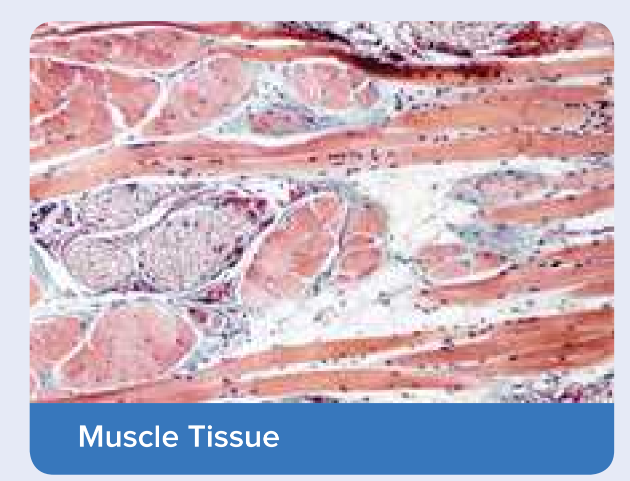
Cells to Tissues

Most multicellular organisms are made of different parts that have different structures. All organisms are made of cells, but cells, although they all have things in common, come in many shapes and sizes. Why is there such a variety of shape and size? Cells must be specialized to perform specific functions. Take **muscle** cells, for example. Muscle cells need to be shaped like long fibers, which allow for movement, and able to store and use energy quickly. Muscle cells are specifically formed to do the job that muscles do for our body. Muscle cells do not work alone. Each cell is very small and must work with hundreds of thousands of other cells to be effective. All around the body, groups of similar cells work together to form **tissue**.

Tissues to Organs

In a muscle, the cells are bundled together to form tissues. Take a look at the muscle that is on the front part of your upper arm, between your elbow and your shoulder. Bundles are organized to form the structure of this and other muscles.

Each muscle is considered an organ. An organ is a part of an organism that has a specific job to do.

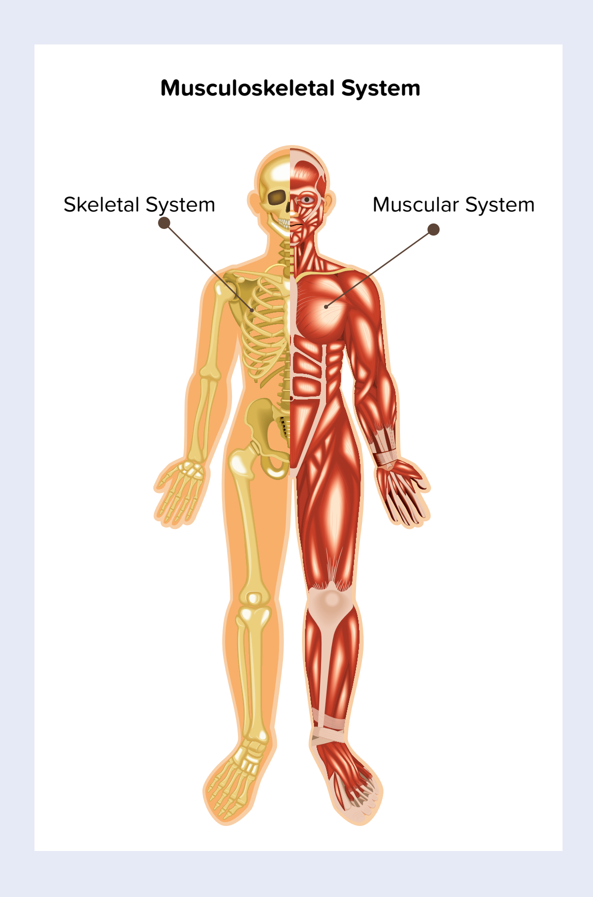


Muscle Tissue

Photo Credit: (a) MikhailSh / Shutterstock.com (b) Macrovector / Shutterstock.com

Organ to System

There are many organs in the body. Most organs work as one part of a larger, interconnected system. Systems are groups of organs that work to carry out one common job for the body. For example, **musculoskeletal system**. It is made up of bones, ligaments, tendons, and cartilage. Each of these organs is responsible for its own specific role, but each organ contributes to the success of the system in performing its job.



Organ Systems to the Body

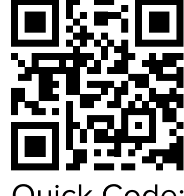
No system in the body can work alone to maintain life. Many simple tasks that you complete everyday require multiple systems to work at the same time. Playing in a football game requires cooperation between your respiratory system, circulatory system, nervous system, musculoskeletal system, and your excretory system, just to name a few.

Draw a model that represents the structures of cells, tissues, and organs in the human body.



Activity 5

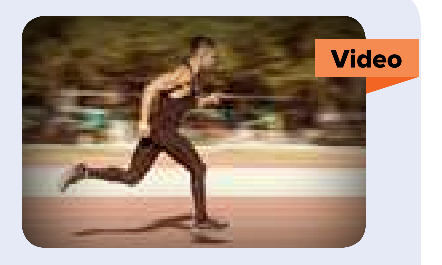
Observe Like a Scientist



Quick Code:
egs6035

Moving Muscles

Let's think about a simple task many of us do every day—picking up a glass of water from the countertop. What body systems are involved? How do the systems work together? Watch the video and read the text. Then, talk together with your group about how an arm bends.



Make a fist. Now bend your elbow and lift your fist toward your shoulder. How are your muscles able to make this movement? Take your opposite hand and feel your muscles along your arm as you repeat this movement. How do the muscles move? Skeletal muscles move a bone as they **contract**, or shorten in length. The movement of fingers, legs, arms, and other body parts is possible because of this process. A muscle can only exert force when it contracts. The contraction of the muscle moves a bone in just one direction.



Talk Together Show examples of other muscles in your body, and explain how they move.

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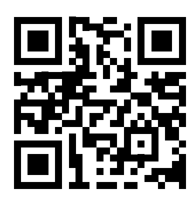
Life Skills I can apply an idea in an innovative way.



Activity 6

Observe Like a Scientist

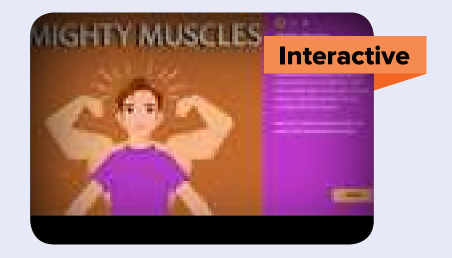




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egs6037

Mighty Muscles

You have seen how the arm bends by the contracting and expanding of the arm muscles. What about our body's other muscles? Are skeletal muscles the only muscles we have in our bodies? Complete the interactive. Discuss your findings within your group as you learn. Then, read the companion text to help clarify new ideas. Once you have finished, respond to the questions at the end of the lesson.



All muscles must contract and relax to allow for movement. Some muscles are involuntary. This means that the movement is automatic and is not something you control. Others are voluntary, which means you control the movement.

Heart muscle is involuntary muscle contracts and relaxes without any rest. Your heart pumps blood through your body, sending oxygen to your cells with each heartbeat.

You blink about 10 times a minute without even thinking about it. The eyelid muscles, also involuntary, contract when you close your eyelid. Other muscles surround the eyeballs to help you move your eyes in different directions.

Bending the elbow takes two different voluntary muscles. The muscles in the front of your upper arm contract when the arm is bent, while the muscles in the back of your arm relax. To straighten the arm, the muscles in the back contract while the muscles in the front relax. Muscles that move your bones are skeletal muscles.

Two important neck muscles work when you move your head up and down. One contracts while you lift your head. When you pull your head back down, another contracts. You control the movement of these muscles, so they are voluntary.

Life Skills **I can anticipate and summarize outcomes.**

When you turn your hand over, it takes the action of two important voluntary muscles in your forearm. One contracts when you put your palm face up. Two muscles contract when you turn your hand back over, with your palm facing down.

On each side of your body, you have two important abdomen muscles, or abdominals. When you twist your body to one side, the two muscles on that side contract together, while the muscles on the other side relax.

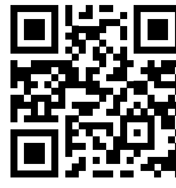
- **What is true of the way in which all muscles work?**
- **What kind of muscle is responsible for the heart's pumping action?**
- **When a pair of skeletal muscles performs an action, how do the two muscles work together?**
- **What is the difference between an involuntary muscle and a voluntary muscle?**

Life Skills **I can anticipate and summarize outcomes.**



Activity 7

Evaluate Like a Scientist



Quick Code: egs6038

Systems Work Together

Read the paragraph and highlight the facts about the endocrine system. Share what you have highlighted with the members of your expert group. Decide on the three to five most important facts. Record these facts in the chart. You will share these with your home group.

Once you have returned to your home group, listen to the other experts. Record what you learn from them in the second section of the chart.

Endocrine System

Your body has a physical reaction to stress or danger. One way to describe this collection of symptoms that you may experience is called "fight or flight." When faced with a threat, your body gets ready to fight a threat or to run away from it. First, your eyes see danger. Then, your eyes send a signal out to the brain. Next, your brain sends a signal out to the body to initiate a reaction to the threat. The **endocrine system** controls this reaction. This system is made up of **glands** that release hormones that help the human body prepare to react. The same system keeps body temperature and blood pressure under control. When you feel stressed, other systems become involved as well. Your muscles tense, and your heart rate and breathing also speed up. When might you feel the fight-or-flight reaction?



Feeling Stressed

Photo Credit: Prostock-studio / Shutterstock.com

Life Skills **I can reflect on the contribution of individuals to the group.**

Circulatory System

During a fight-or-flight scenario, hormones released by the endocrine system need a way to travel around the body. The **circulatory system** transports blood, gases, hormones, and nutrients throughout the body. The circulatory system includes the heart muscle and the blood vessels that allow blood to flow through the body. These vessels include veins, arteries, and capillaries. When the body is faced with danger, the heart begins to beat quickly. As the heart beats faster, it pushes blood to the muscles, heart, and other vital organs, and blood pressure increases.

Respiratory System

The circulatory system depends on the **lungs**, which are the main organ of the respiratory system.The lungs take in oxygen and remove carbon dioxide as part of the circulatory and respiration processes. The respiratory system is the system of organs and tissues that help you breathe. When the diaphragm muscle contracts, the lungs take in air. When the diaphragm relaxes, air is pushed out of the lungs. Your bloodstream delivers oxygen to all your organs and other tissues from the lungs. During the fight-or-flight response, rapid breathing and an increased heart rate allow the body to send more oxygenated blood to the muscles and brain. By preparing your body to act, you are more ready to perform under pressure.

Review what you learned as an expert and from your home group.
Complete the following chart with your new ideas.

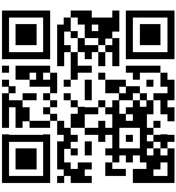
Facts	Parts of the Endocrine System and Role in Fight or Flight	Parts of the Circulatory System and Role in Fight or Flight	Parts of the Respiratory System and Role in Fight or Flight
What I learned from reading and my expert group			
What I learned from my home group			



Activity 8

Analyze Like a Scientist





Quick Code: egs6040

Getting Fuel

For any of the human body systems to function, the body needs energy provided by food. The job of the digestive system is to break down food into nutrients that the body can use for energy and growth. Read the following text. As you read, use the diagram to follow the movement of food through the digestive system.

Getting Fuel

Many body systems work together to keep your body working properly. These systems need fuel to run. These fuels are the foods we eat. Food contains different nutrients that include carbohydrates, fats, and proteins. These complex nutrients must be converted into simpler substances before they can be used to power the body's cells. Inside cells, some of these substances are used in the process of respiration.

Digestion

The body has a system that has evolved to convert the complex foods we eat into simpler substances. This system is called the digestive system, and the process of conversion is called **digestion**.

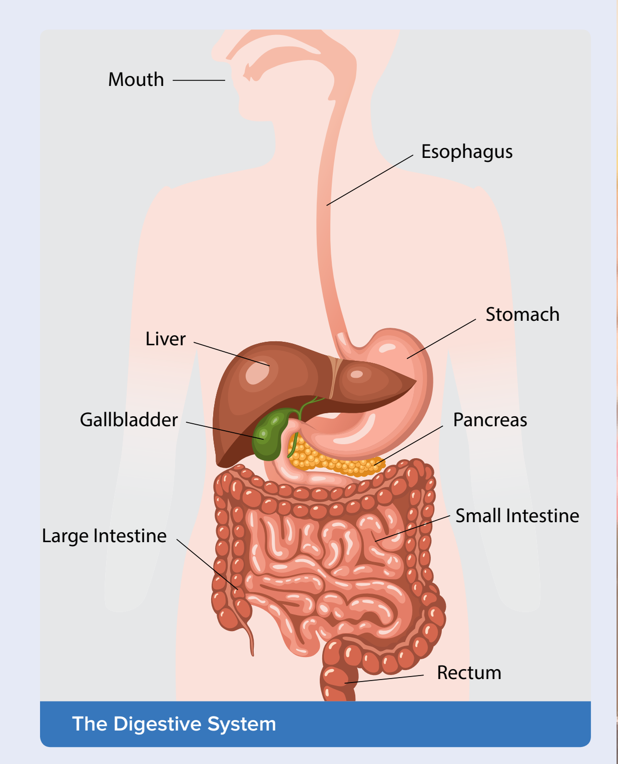
The Beginning of Digestion

Digestion begins when you put food in your mouth. Jaw muscles create movement and help your teeth to chew. Chewing breaks up the food and increases its surface area. This makes it easier for chemicals produced by the endocrine system, called enzymes, to break down and digest food. In the mouth, the addition of saliva softens the food, adds an enzyme, and begins the chemical breakdown. Muscles then push the food down your esophagus to your stomach.

Life Skills **I can apply an idea in an innovative way.**

Breaking Down Food

The continuous churning and the secretion of the stomach's digestive fluids—acid and enzymes—further break down the food. Additional enzymes from the **pancreas** and **gallbladder** also assist in the chemical breakdown once the food moves on to the small intestine. Absorption of nutrients takes place in the small intestine. These nutrients are carried away from the digestive system in the blood, through capillaries in the wall of the small intestine. Food not absorbed is passed into the large intestine, also known as the colon. Unused material then exits the body as stool.



The Digestive System

Food Waste Leaves the Body

Some of the food you eat gets digested in the stomach. Undigested food enters the large intestine as a soupy mixture. The large intestine reabsorbs most of the water, changing undigested food into a solid mass called feces, or stool. The last section of the large intestine is the rectum. The rectum stores feces until it is expelled through a muscular opening at the end of the rectum called the anus.

Transporting Nutrients

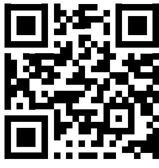
Where do the nutrients go once they are in the blood? They are transported to different organs via the circulatory system. The heart is one of these organs. Some nutrients are used immediately. The rest are stored. For example, the liver and muscles can store glucose sugar. They convert it into a special energy storing substance called glycogen (animal starch). This stored energy comes in handy if you find yourself in a fight-or-flight situation. The liver and muscles can then release the glucose when it is needed. Some nutrients are stored as fat.

What six words could you use to describe the function of the digestive system?



Activity 9

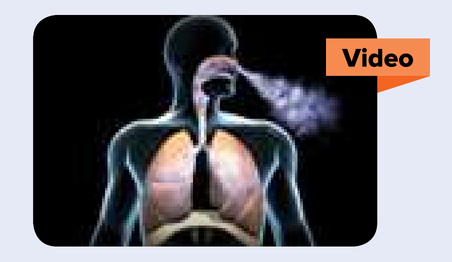
Observe Like a Scientist



Quick Code: egs6041

The Excretory System

Your body must take in food, water, and air every day to function properly. Not all of the materials we consume are useful. Also, some of the processes in our body produce waste products. How does the body get rid of these substances? As you read the following text and watch the video, look for the answer to this question.



Our body is a complex system that is always working to keep us alive. Many of the biologic processes that occur daily manufacture waste products. Eliminating waste is a very important function of the human body. It is called excretion. The **excretory system** collects waste materials produced by cells and removes the waste materials from the body. If your body did not remove waste, you would become sick. Your digestive system is not involved in excretion. The term *excretion* is used only when waste materials must pass through a membrane to leave the body. The systems involved in the process of excretion are your skin, respiratory system, and **urinary system**. When you sweat, waste leaves the body through pores in your skin. When you exhale, carbon dioxide leaves your body as waste. The urinary system removes waste products from your blood.

Your kidneys play a very important role in the urinary system. They constantly clean and filter your blood, up to 300 times a day. First, a large artery brings blood into each **kidney**. Tiny blood vessels branch off and pass through part of each **nephron**. Nephrons are microscopic filters that remove harmful substances from the body. The nephrons filter substances from the blood. One of the most important waste products eliminated by the kidneys is called urea. It comes from the breakdown of proteins. Blood cells and proteins are too large to pass through the filter (nephron), so these substances stay in the body. After the filtering is complete, urea, other waste products, and water become urine. Urine leaves each kidney through a slender tube and collects in the **bladder**. The bladder empties through another tube called the **urethra**. Urination is the process of expelling urine from the body.

Your body truly is an incredible food-processing machine. From the minute you take your first bite of food or drink a glass of water, your body gets busy changing the food you eat into the nutrients and energy you need to live and grow.

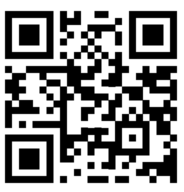
How is waste removed from the body?



Activity 10

Investigate Like a Scientist

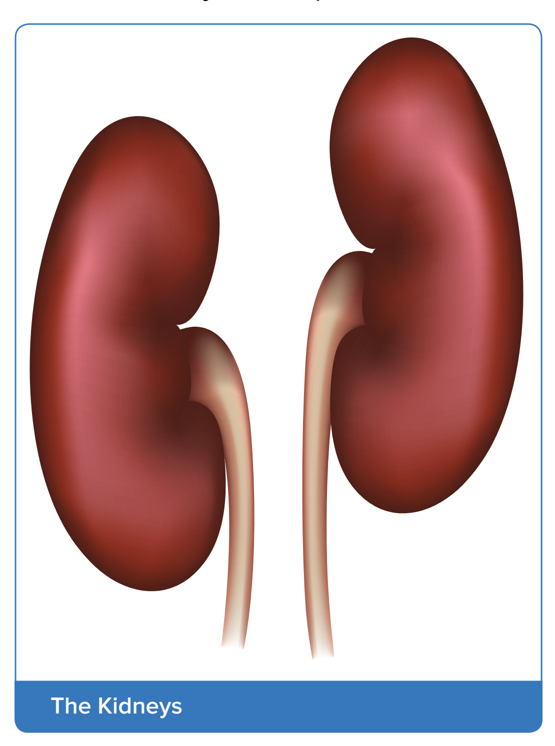




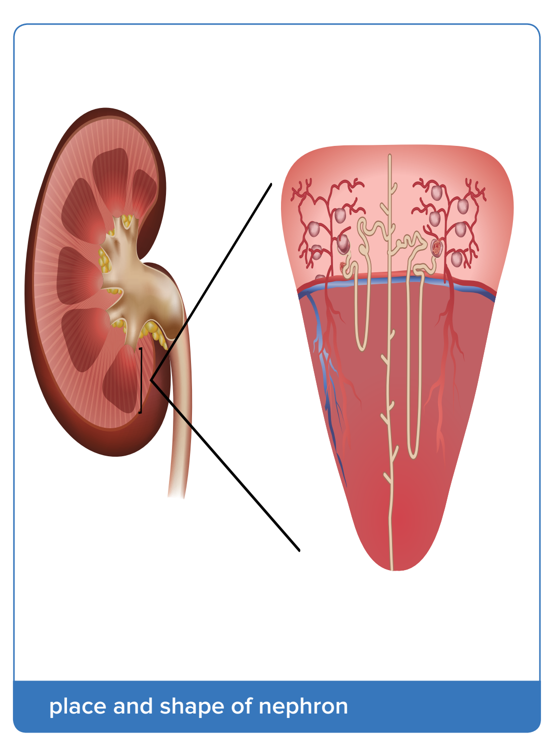
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Hands-On Investigation: Getting Rid of Waste

Earlier, you learned that the kidneys are a filtering system for the blood. Engineers design special devices for people whose kidneys are not working properly. These devices filter the blood to remove waste materials. Why is it important for the blood to be filtered?



The Kidneys



place and shape of nephron

Photo Credit: (a-b) TimeLineArtist / Shutterstock.com

What materials do you need? (per group)

- Cone-shaped paper filters, 2 to 3
- Salt, 30 g
- Red kidney beans, 15 g
- Rice, 15 g
- Stapler and staples
- Large transparent bowl or beaker
- Water
- Funnel (optional)



Life Skills **I can carry out solutions and evaluate results.**

Make a Prediction

Today, you will develop a model that you could use to show how kidneys filter waste products found in blood.

Think about the various substances found in blood that get filtered by the kidneys. What are some ways you could show how the kidneys work?

What is the problem?

What ideas do you have to solve the problem? Develop a plan for your model and draw a rough sketch of what your model would look like. Your plan should include a description of the structure and function of each part of the kidney. Your sketch should show the direction substances move in your model kidney.

How will you know your idea works?

What Will You Do?

Now, work with your group to construct your model using the materials provided by your teacher. Remember that you will use the materials to represent the different parts of the kidney. Make sure that you have included items to represent blood cells, proteins, urea, and nephrons. If you have not included these in your model, be sure to add these to your sketch now.

Test your design. Draw or write to show how you tested it.

Think About the Activity

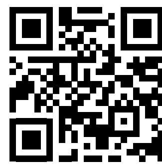
Think about the model you developed and answer the following questions.

- **What worked?**
- **What did not work?**
- **What could work better?**
- **How is your model similar to and different from an actual human kidney?**
- **What are the advantages to using a model to study the kidney instead of the real thing?**



Activity 11

Evaluate Like a Scientist



Quick Code: egs6044

Systems Working Together

You have been learning about different body systems and how they work together. As you complete these items, think about the different organs and organ systems that are involved in helping our human bodies function.

Understanding Excretion

Read each statement. Select the statement that correctly describes the excretory system.

A. The excretory system includes the stomach, pancreas, and intestines.
B. The excretory system removes waste from all parts of the body.
C. The excretory system uses blood to carry oxygen from the lungs and food from the digestive organs to the body.
D. The excretory system breaks down food so that it is available to provide energy and nutrients to the body.

Getting Energy

Before completing this item, review the different steps your body takes to get nutrients and energy from the food you eat. Work together with your teacher and your classmates to make sure that you can explain how the different systems in your body work together. Your body systems must work together to keep you healthy. Each system depends on all of the other systems. If one system does not do its job, the other systems will not be able to function well. **In the chart that follows, write the name of each organ system next to the description of how it helps you get the energy you need.**

digestive system
circulatory system
excretory system
muscular system
endocrine system

Process	Organ System
A person takes a bite of food and chews it into smaller pieces. Muscles in the jaw make it possible to chew.	
Enzymes are released and mix with the food to help break it down even further.	
The intestines absorb nutrients from the food, and undigested food moves into the rectum.	
Waste materials produced by cells are collected and removed from the body, filtered through the kidneys.	

Life Skills **I can carry out solutions and evaluate results.**



Activity 12

Record Evidence Like a Scientist





Quick Code:
egs6046

Circle Back: Danger Response

Now that you have learned about different systems in the human body, look again at Danger Response. You first saw this in Wonder.

How can you describe Danger Response now?

How is your explanation different from before?

Look at the Can You Explain? question. You first read this question at the beginning of the concept.



Can You Explain?

How does my body function as a system?

Now you will use your new ideas about Danger Response to defend a claim using evidence. First, write your claim. A claim is a one-sentence answer to the question you investigated. It answers, What can you conclude? It should not start with a *yes* or *no*.

Record your claim.

Next, write a scientific explanation with evidence that supports your claim. Evidence can come from videos, readings, interactives, and Hands-On Investigations.

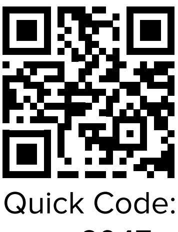
Record your evidence-based scientific explanation.

Choose one additional idea that you would like to research. **What would you do to learn more? What resources would you use to extend your research? How would you build upon your investigations?**

Record your research, and the resources you used.

Life Skills **I can apply an idea in an innovative way.**




Quick Code:
egs6047



Technology of Diabetes Treatments

You already know the job of the endocrine system is to produce hormones that regulate many processes in the body. Diabetes is a disorder of the endocrine system. People with this condition are unable to make or use insulin, a hormone that regulates the amount of sugar that the body can use for energy. Read the text and watch the video. Then, talk about what careers may be involved in helping people with diabetes stay healthy.



One of the most well-known disorders of the endocrine system is diabetes. When people have diabetes, their bodies either cannot make insulin or cannot use it. Therefore, sugar stays in the blood and causes many problems.

The pancreas is the organ that produces insulin. If it is functioning correctly, this organ produces the right amount of insulin to regulate the amount of sugar in your blood. In people with diabetes, the pancreas is not working correctly, so they must carefully monitor how much sugar is in their blood and not allow it to get too low or too high.

There are different kinds of technologies used to treat diabetes and for diabetics to selfmanage their condition from home. Many people with diabetes must give themselves regular shots of insulin. An insulin pump is a device that is attached to the body that regulates blood sugar levels with automatic insulin injections. Researchers are now working to develop an artificial pancreas so that people with diabetes would not need the external pump, but rather would have an artificial internal organ that could deliver insulin as needed.

Talk Together People with diabetes must be careful to eat healthy, exercise, and see their doctor regularly. What other careers could be involved in helping people with diabetes stay healthy? Can you think of creative and innovative ways that technology could help people with disorders like diabetes?

Unit Project Connections: The Body as a System

How does your further understanding of human body systems connect with the Unit Project, Support System? What research and resources will you need to complete the Unit Project?

CONCEPT 1.3

Energy as a System

Student Objectives

By the end of this concept:

- I can develop a model to explain how magnetism, electricity, and force are related phenomena.
- I can recognize the essential components of an electric circuit.
- I can argue from evidence that various factors affect the strength of electric and magnetic forces.
- I can classify materials as conductors and insulators according to their ability to conduct electricity.
- I can compare using evidence the results of connecting circuits in parallel and series circuits.

Photo Credit: raigvi / Shutterstock.com

Key Vocabulary

- attract
- circuit
- closed circuit
- conduct
- conductor
- electric current
- electricity
- electrons
- generator
- gravity
- insulator
- magnet
- magnetism
- open circuit
- parallel circuit
- repel
- resistor
- series circuit
- switch
- thermostat
- turbine



Quick Code:
egs6050



Activity 1

Can You Explain? Energy as a System





Photo Credit: (all)Gr... / Shutterstock.com, (b)Grigvovan / Shutterstock.com

Have you ever looked behind a wall in a building and noticed the many wires leading to outlets and light fixtures? Wires connect devices that are powered by **electricity**. Electrical poles supporting wires outside and the wires inside walls are all examples of electric circuits. Every time you flip a light **switch** or turn on an electrically powered device, you use electrical circuits. What do you already know about circuits and switches?

How is a circuit a system?

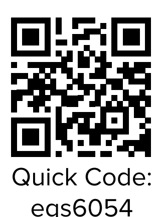


Quick Code:
egs6053



Activity 2

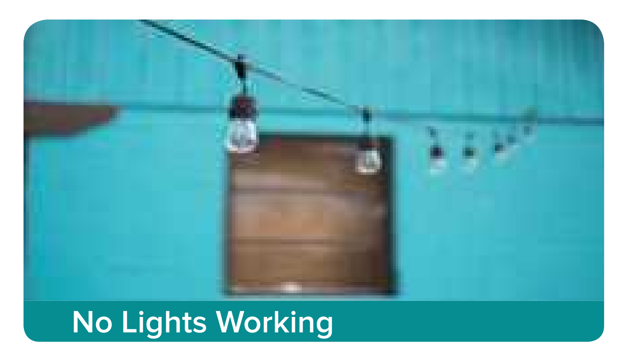
Ask Questions Like a Scientist



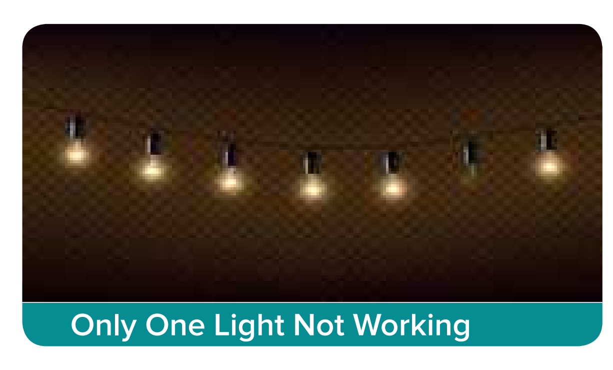
Quick Code: egs6054

Light Bulb Trouble

In each of the two images, only one light bulb has burned out. The burned out bulb has affected each strand differently. Think about what you have learned about circuits. Compare the two images. Why are all the lights off in one image and only one light is off in the other image? Then, respond to the question that follows.



No Lights Working



Only One Light Not Working

Why does a string of lights still work when one light bulb is broken?
Write three questions you have and share them with the class.

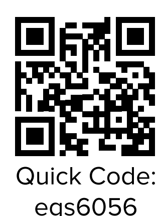
I wonder . . .

Once you have recorded your Wonder statements, share them with a partner. Add any new questions that come up in your discussion to your list.



Activity 3

Observe Like a Scientist



Quick Code:
egs6056

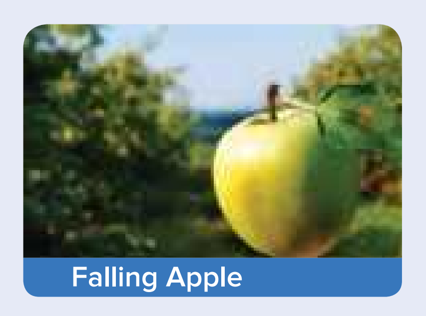
Magnetism and Gravity

Gravity and **magnetism** are forces that affect us every day. These two forces are different from other forces you may have already learned about because objects do not have to come into contact with one another to be affected.

Read the text and think about how these two forces are alike and different from each other.

How Are Gravity and Magnetism Similar?

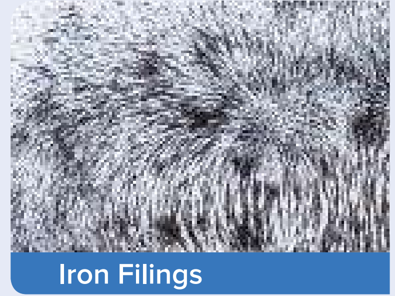
Gravity at Work



Falling Apple

Gravity is a force that affects everything with mass. Earth has great mass compared to everything located on its surface. Gravity holds you to the ground. All objects on or near Earth's surface are pulled toward the center. Think about throwing an apple into the air. It will stop moving upward at some point and fall back to Earth. This is due to gravity. You will always experience the downward pull of gravity. There are two factors affect the force of gravity. These factors are distance and mass. As the distance between objects and the center of the Earth increases, the effect of gravitational forces decreases..

Magnetism at Work



Iron Filings

Magnets have a space around them, in which they exert a force called magnetism. This force allows the **magnet** to pull, or **attract**, certain materials and other magnets to itself. The force also allows the magnet to push, or **repel**, some materials away without making direct contact.

Magnetism affects certain objects that are in its magnetic field. Like gravity, we cannot see the magnetic field. We can only observe its effects. The best way to "see" the magnetic field is to allow a magnet to interact with small filings of iron. The pattern that the iron filings make near the magnet is the outline of the magnetic field. Magnets are made of iron and other materials. Magnets can attract or repel other magnets. Magnetism only occurs between specific materials referred to as magnetic materials, while materials that are not attracted to magnets are called non-magnetic materials.

Consider how gravity and magnetism are similar and different. Respond to the questions.

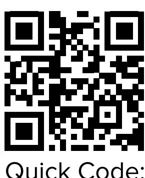
- **How are magnetism and gravity similar and different?**



Activity 4

Investigate Like a Scientist





Quick Code:
egs6058

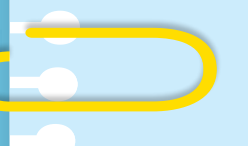
Hands-On Investigation: Does It Attract?

What experiences have you already had using magnets? Let's test your understanding of magnets and materials that can be attracted by a magnet.

Make a Prediction

Choose items to test. Before testing, predict whether the items will be attracted by a magnet. Materials that are attracted to a magnet are called magnetic. Materials that are not are called non-magnetic..

Material	Prediction: Magnetic or Not Magnetic	Results	Reason for Results



What materials do you need? (per group)

- Magnets
- Materials for testing (such items as steel pins, paper clips, steel or iron nails, cardboard, copper, aluminum foil, and plastic)
- Ruler



Life Skills **I can carry out solutions and evaluate results.**

What Will You Do?

In this activity, you will conduct two separate investigations. First, you will test materials to see if they are magnetic. Next, you will explore how the size of the magnet and distance between the magnet and an object affect the level of attraction between the magnet and magnetic items.

1. Collect the items you will be testing.
2. Test each item to determine whether the material is magnetic or not magnetic. Record the results in the chart where you made your predictions.
3. Take a look at your data. Consider what is the same about the objects that you listed as magnetic.
4. Use only the magnetic materials to complete a second investigation using a ruler and magnets of different sizes. Use these supplies to test how close different magnets must be to an item before it is attracted.
5. Place each item at the 0 cm end of a ruler. Slowly bring a magnet closer and closer to the object. Record the centimeter mark at which the object is attracted to the magnet.
6. If time allows, experiment with the magnets to see if you can demonstrate the opposite of attraction by making the magnets repel. Discuss your findings with your class.

Material	Size of Magnet	Distance from Object at Attraction (cm)	Conclusion

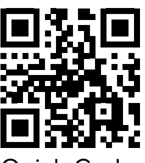
Think About the Activity

- **What did all of the magnetic materials have in common?**
- **Does distance affect whether an object is attracted to the magnet?**

Activity 5

Observe Like a Scientist





Quick Code:
egs6060

Generating Electricity

Do you know where the electricity that you are using right now comes from? Electricity can be generated in many different ways. Consider the fact that energy can neither be created nor lost. What does it mean to generate electricity? Watch the video and read the companion text that follows.

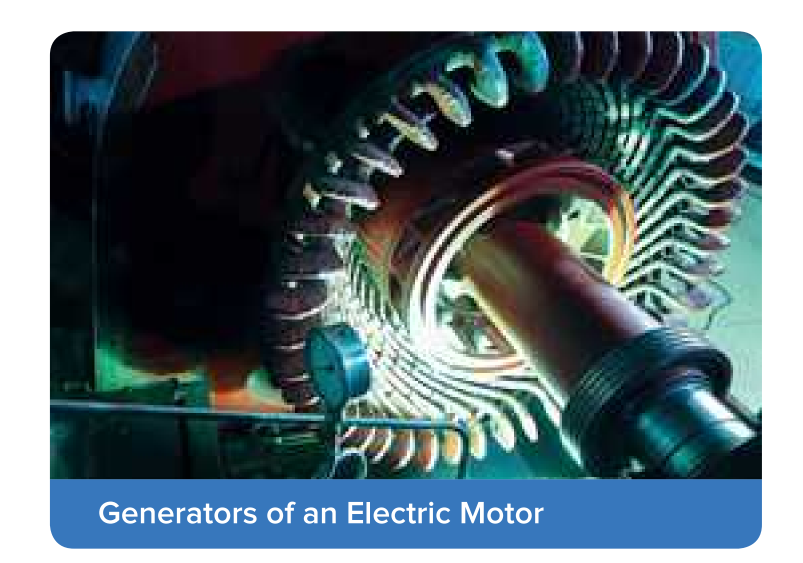
A **generator** uses magnets and conductive wires to produce electricity. Generators change mechanical (kinetic) energy into electrical energy. Generators produce electricity to light homes and operate devices such as computers and refrigerators.



In a generator, many large magnets spin at a high rate of speed. The spinning magnets create an electrical charge on the surrounding wires, and electricity is produced. Different forces like water from a dam flows across the **turbine**, causes the magnets to spin. Wind-powered turbines can be used in the same way. Other sources of fuel, such as oil and coal, are used to make water boil. This creates steam, which causes a turbine to spin, and this indicates the effect of different forces on the spinning.

Look at the image shown. Think about the different parts of a generator.

Write or draw a diagram that shows an electric generator.



Generators of an Electric Motor



Activity 6

Evaluate Like a Scientist



Quick Code:
egs6055

What Do You Already Know About Energy as a System?



Magnets and Electricity Can Work Together

Electricity

What do you already know about electricity and magnetism?
Complete the paragraph using the word bank.

metal core	electric current	magnetic field

An ____________________ is the movement of charged particles through a conducting wire. When an electric current flows through a wire, a ____________________ is produced around the wire. If the wire is wrapped around a ____________________, the magnetic field produced by the flowing current is strengthened.

Magnetic Attraction

Which of the following do magnets attract?
Select all that apply.

A. aluminum
B. iron
C. wood
D. nickel
E. plastic
F. gold

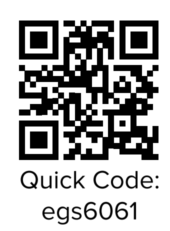


Magnets



Activity 7

Think Like a Scientist



Quick Code:
egs6061

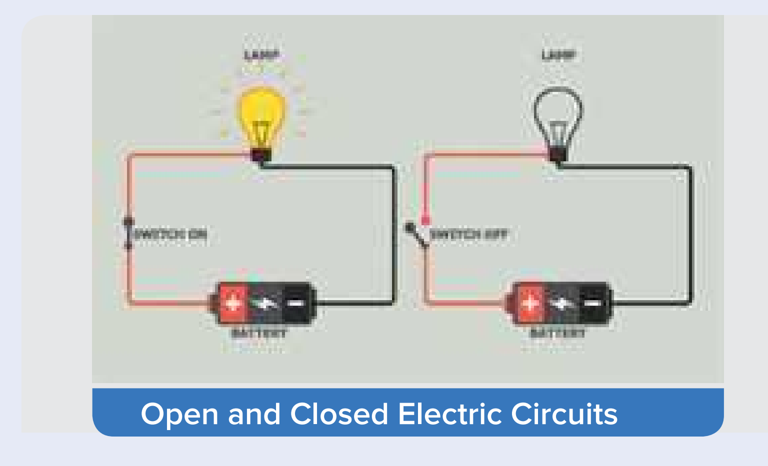
Components of a Circuit

You know that magnets, generators, and turbines can be used to generate electricity. Use what you already know about electricity to better understand the parts of a **circuit**. Highlight important information that will help you answer the question: Can You Explain?

Electricity and Circuits

Electricity

We know that electricity powers devices and turns on lights. But what is electricity? Electricity is a form of energy that comes from a flow of electric charges moving along a conductor. In order to do work, charges, called **electrons**, must travel in a steady stream, known as an **electric current**. A closed electric circuit is a path that allows for the movement of an electric current.



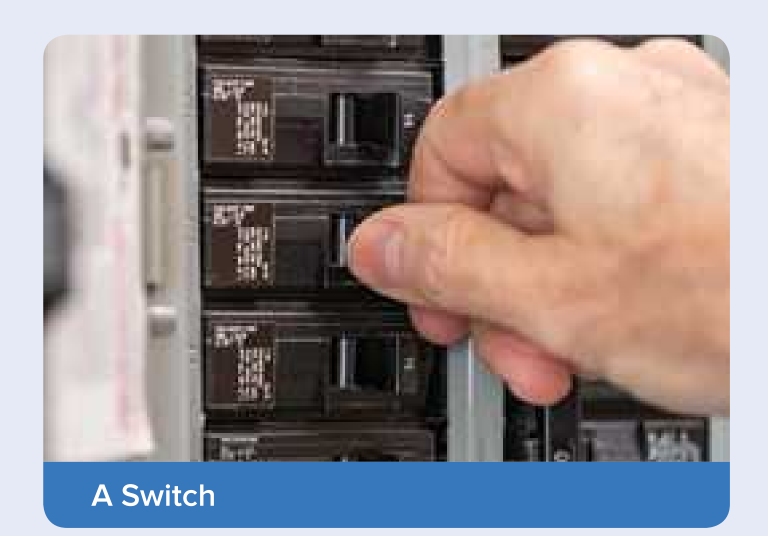
Open and Closed Electric Circuits

Closed Loop

For electric current to flow through a circuit, the loop must be closed. This means it must begin and end in the same place, without any breaks in the loop. There must be a source of electricity. This source could be a battery or a wall socket that brings in current from power lines connected to the building. Most electric circuits have metal wire, a power source, a switch, and a device that uses the power. All of these parts **conduct** electricity.

Photo Credit: The Toidi / Shutterstock.com

The Switch


A Switch

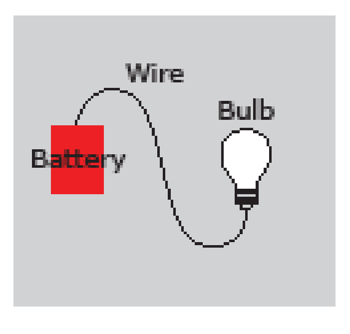
A switch is the most common tool that people use to open and close a circuit. A switch can be manual. For example, a wall switch for lights is a manual switch. In one position, the switch completes the path and closes the circuit. In a **closed**, current flows through and the lights turn on. In the other position, the switch breaks the path and opens the circuit. When it is an **open** the current is broken and the lights are off. A switch can also be automatic, such as the internal switch on a **thermostat**, which continually adjusts the temperature inside appliances, such as a refrigerator, by turning off and on.

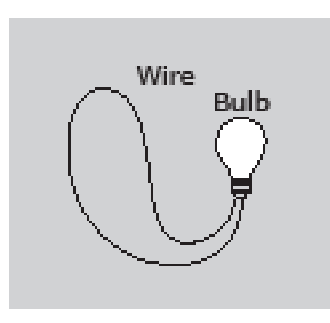
Current Safety

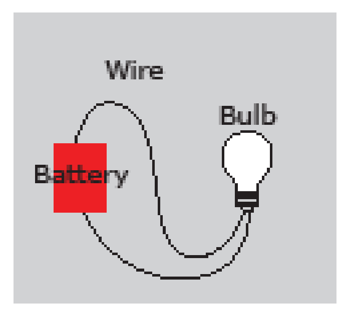
Touching a live, non-insulated wire will give you an electric shock and could even kill you. This is because our bodies contain a lot of water, and water is a good **conductor** of electricity. A conductor is a material through which energy flows easily. Other good conductors of electrical energy are metals such as copper and aluminum. To protect people from electric shock, most electrical wires are coated with rubber or plastic. Rubber and plastic are good insulators. An **insulator** is a material through which energy does not flow easily. Insulators resist the flow of electricity.

A Working Circuit

Examine the circuits in the diagram. Select the circuit that will cause the bulb to light up.







A. Circuit (1)

B. Circuit (2)

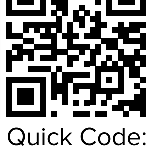
C. Circuit (3)



Activity 8

Investigate Like a Scientist





Quick Code:
egs6063

Hands-On Investigation: Conductors and Insulators

Look at the image. Have you ever asked yourself what these cords are? On the surface, they seem to be some kind of flexible rubber or plastic with some sort of metal prongs on the end. The rubber or plastic coating surrounds metal wires that connect to the metal prongs on the cord's plug. Why do electrical cords have metal wires surrounded by a plastic coating?



Electrical Plugs

What materials do you need? (per group)

- 9-volt battery
- 2 Wires with alligator clips at each end, OR 2 pieces of insulated wire, 10 to 20 cm long, with 3 cm of insulation stripped off each end
- Small LED or other light bulb with two wire leads connected
- Roll of electrical tape
- Materials for testing (such items as aluminum foil, other metallic items, rubber, wood chips, and cloth)



Life Skills **I can carry out solutions and evaluate results.**

Make a Prediction

How will you know which materials are conductors and which are insulators? In this activity, each group will test several materials and classify them according to their electrical conductivity. Which materials do you think will conduct electricity?

Which materials do you think will conduct electricity?

What Will You Do?

1. Use the wires, bulb, and a battery to create a circuit with your group.
2. Test each material and record your findings. Continue testing until you have three materials that conduct and three that do not.
3. Then, complete the table and answer the questions.

Complete the data table by listing each material in the appropriate column.

Conductors	Insulators

Think About the Activity

Think about the results you recorded and answer the following questions.

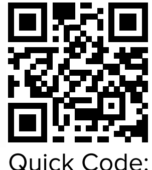
- **How would the results of your experiment change if you wrapped one of the conductors in plastic?**
- **What are the common properties of conductors and insulators?**
- **How are conductors and insulators used in your home to keep you safe from electric shock?**



Activity 9

Observe Like a Scientist





Quick Code:
egs6065

Construct an electric Circuit

Can an electric current flow through all types of materials? Explore the effects of conductors and insulators in a circuit. Complete the interactive and read the text. Then, answer the questions that follow.

Conductors and Insulators



Conductors are materials that allow electrons to flow through them easily. If a conductor, like a metal paper clip, is placed in a circuit with a battery and bulb, electricity will flow, and the bulb will light. On the other hand, electrons cannot easily flow through insulators. This means insulators do not conduct electricity. If an insulator, like an eraser, is placed in a circuit with a battery and bulb, electricity will not flow, and the bulb will not light.

What type of material coats wires and plugs to keep you safe when you are handling them? It is often plastic. Plastic is an insulator. Insulators stop the flow of electricity, keeping you safe from getting shocked by the current.

Electric resistors are parts of a circuit that limit the flow of electrical current. Resistors might be used to slow the flow of electrons through a circuit. This might be done to limit damage to the components of a circuit, resistors can be found in some devices such as toasters, microwaves, and electric stoves.

- **Explain the importance of insulators.**

Life Skills **I can predict possible outcomes of an event.**



Activity 10

Observe Like a Scientist



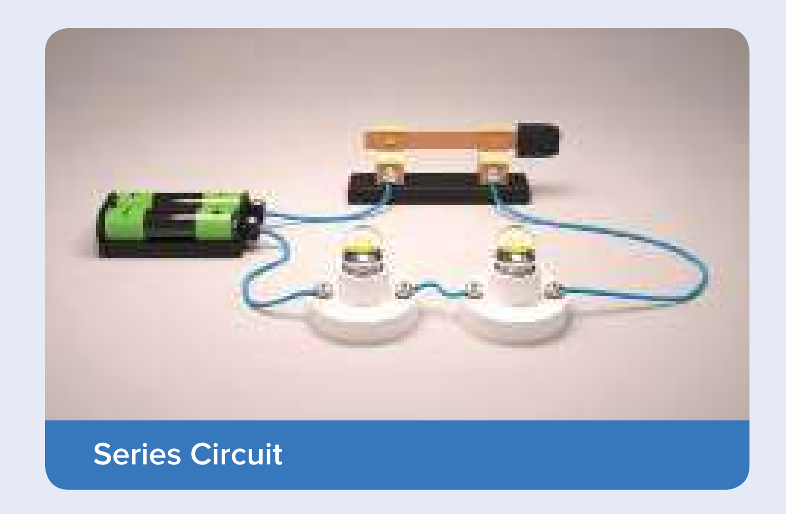
Quick Code:
egs6066

Electric Circuits: Series versus Parallel Circuits

As you watch the video and read the text, consider the following questions: What is the difference between series and parallel circuits? What are some examples of when these types of circuits are used? Be prepared to discuss your responses with a partner, using evidence and reasoning.

There are two ways in which a circuit can be connected. The first is called a **series circuit**. To make a series circuit, all the components must be connected in a single loop. The current can only flow along one path from one side of the energy source—through the device using the energy.

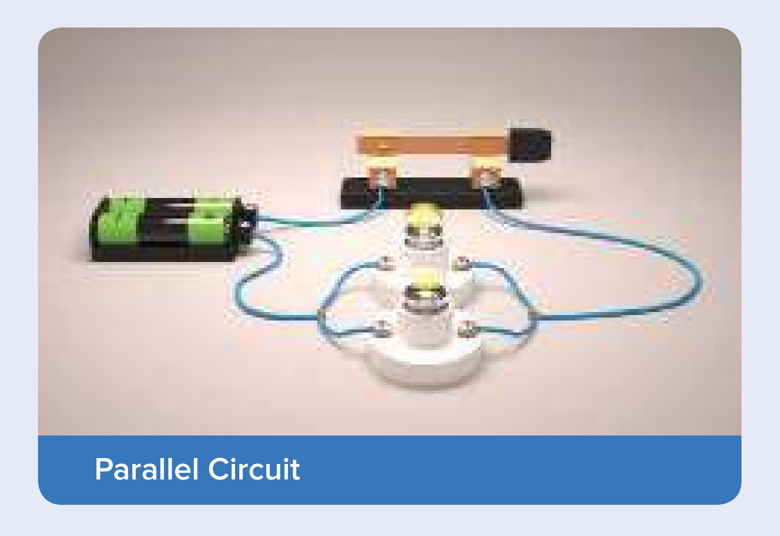




Series Circuit

With a series circuit, you can operate two lights on the same circuit. The only problem is that if one light bulb blows out or is disconnected, the other one will not work.

You can set up an electric circuit so that you can operate several lights all at the same time and turn one off without affecting the others. This is called a **parallel circuit**. A parallel circuit has an energy source, conductors, and more than one load, such as two lights. However, the lights are on two different branches of the circuit. In a parallel circuit, you can turn off one light bulb and the other bulb will remain lit.



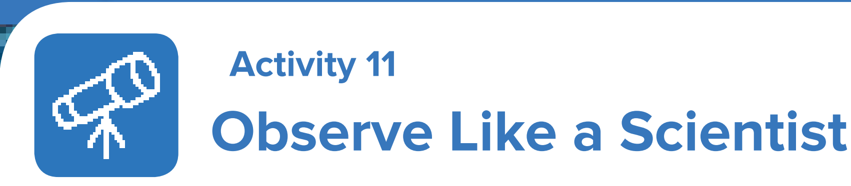
Parallel Circuit

A parallel circuit is the type of circuit you would find in your house. You can operate a blender, toaster, and TV all at the same time, but if you turn one off, the others will continue to work just fine. That is because they operate on a parallel circuit. Entire towns and cities are part of a circuit. The energy source is the power plant, which has generators that push out electricity. Electricity travels along conductors called power lines into all kinds of electrical equipment in homes, businesses, and factories.

Photo Credit: (a) raigvi / Shutterstock.com, (b) harygit / Shutterstock.com

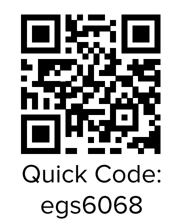
- **What is the difference between series and parallel circuits?**
- **What is an advantage to using parallel circuits?**

Draw a parallel electrical circuit and another one in series.



Activity 11

Observe Like a Scientist



Quick Code:
egs6068

Magnetism and Electricity

As you watch the video and read the text, consider the following questions: How can a magnet generate electricity? Be prepared to discuss your responses using evidence and reasoning.

A scientist conducted an experiment during which he tightly coiled a wire around a hollow cylinder. He connected this coil to a galvanometer, a device used to detect the passage of small electrical currents. He then took a bar magnet and placed it in different proximities in relation to the coil. While the magnet sat at rest away from the coil, the needle of the galvanometer did not move, indicating there was no current flow. But once the magnet moved toward and into the cylinder, the needle moved to one side, indicating that there was an electrical current present.

When the magnet was moved rapidly back and forth inside the coil, the needle also moved quite rapidly, indicating that the faster the magnet moved, the more current was induced. If the number of loops in the coil is increased, there will also be an increase in the movement of the needle, indicating an increase in the voltage. This is the basic principle of mutual interaction between magnetism and electricity, which is now used in electric motors, generators, and transformers.

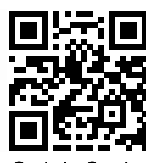
How can a magnet generate electricity?



Activity 12

Record Evidence Like a Scientist

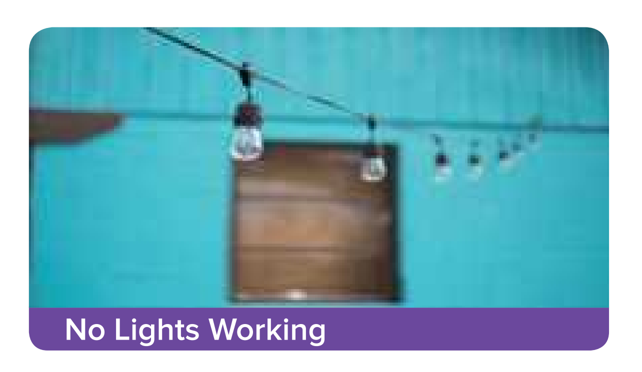




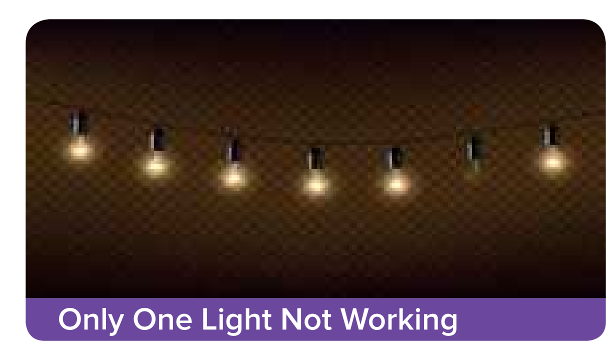
Quick Code:
egs6069

Circle Back: Energy as a System

Now that you have learned about how energy is a system, look again at Light Bulb Trouble. You first saw this in Wonder.



No Lights Working



Only One Light Not Working

How can you describe Light Bulb Trouble now?

How is your explanation different from before?

Look at the Can You Explain? question. You first read this question at the beginning of the concept.



Can You Explain?

How is a circuit a system?

Now you will use your new ideas about Light Bulb Trouble to defend a claim using evidence. First, write your claim. A claim is a one-sentence answer to the question you investigated. It answers, What can you conclude? It should not start with a *yes* or *no*.

Record your claim.

Next, write your scientific explanation with evidence that supports your claim. Evidence can come from videos, readings, interactives, and Hands-On Investigations.

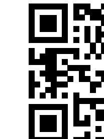
Record your evidence-based scientific explanation.

Choose one additional idea that you would like to research.

What would you do to learn more? What resources would you use to extend your research? How would you build upon your investigations?

Record your research, and the resources you used.







Quick Code:
egs6070

Activity 13

Analyze Like a Scientist

How to Build a Pacemaker

You have learned a lot about electricity in this concept. Previously you learned about several important body systems. How can an electrical system improve the function of a body system? Read the text and then discuss your ideas.

Pacemaker

The heart is an amazing organ. It is a muscle, and its job is to beat consistently for the duration of our lives. The heart has a natural pacemaker that creates electrical currents that it sends out through the heart, causing the heart to contract. When that regulator starts to fail, sometimes we need an artificial pacemaker to keep the heart beating correctly.



Pacemaker

A pacemaker is a battery-operated device that is inserted into the chest and stimulates the heart muscle to beat at regular intervals for patients who have a slow or irregular heartbeat. Battery-operated pacemakers have been in use for over 60 years. To build a pacemaker, you need a battery, an insulated electrically conductive wire and a motherboard.

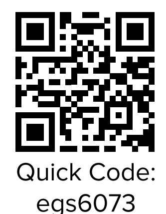
The Future of Pacemakers

The artificial pacemaker has a built-in antenna to send information to physicians so they know how the heart is behaving. The future of pacemakers is looking quite bright. Pacemakers are getting more sophisticated by the year. Pacemakers are becoming smaller too. Today, doctors can place a tiny, effective pacemaker well within the heart with a minimal procedure.

Unit Project Connections: Energy as a System

How does what you learned about electric circuits and energy as a system connect with the Unit Project, Support System? What research and resources will you need to complete the Unit Project?





Quick Code: egs6073

Unit Project: Support System

You have learned a lot about systems. In this project, you will recall what you know about body systems and discover how space travel can affect them. You will then use this knowledge to design a product that could help solve a health-related problem that astronauts face.

Humans in Space

Have you ever dreamed of going to space? This type of travel is not like anything humans experience on Earth. The changes in gravity in space impact our body systems in many ways. Astronauts must be aware of these effects and take special precautions to stay safe and healthy while in space.

The Egyptian Space Agency has asked your class to design a creative new product that may help future astronauts lessen the impacts on their body systems as they spend time on the International Space Station.

What Will You Do?

1. Watch the video What Space Does to the Human Body.
2. Then, with your group, read the text The Human Body without Gravity. Pay close attention to the effects space travel can have on body systems.
3. After reading, discuss what you learned with your group. Choose the body system for which you would like to design a support product. Discuss the problem and how you will solve it.
4. Design your product. Sketch your plan in the space provided. Label all the parts of your product.
5. Present your product to the class.



I can choose the best solution to a problem.

The Human Body without Gravity

You already know that astronauts must undergo intense physical training and examination before they are launched into space. But why must they train so hard? How do the conditions in space affect their bodies? Remember that once astronauts are away from Earth, they no longer experience gravity in the same way that they do on our planet. They exist in what is known as microgravity. Furthermore, astronauts on the International Space Station are moving at more than 28,000 kilometers per hour. This means that they are constantly in free fall. If you have ever seen astronauts floating around in their space suits, you might be able to imagine what weightlessness might feel like.

Space Sickness

Support systems are in place both aboard the space station and in space suits to help meet the survival needs of astronauts and combat the effects of the atmospheric conditions in space. However, life in space is still hard on the human body. Most astronauts experience space sickness, which feels a bit like being carsick, during a period of adjustment to the microgravity environment. Different body systems are affected in different ways.

Space and the Circulatory System

Have you ever gotten a headache or felt dizzy after hanging upside down for too long? Maybe you have held your arm above your head until you "fallen asleep." These actions show the effect of gravity on blood flow.

Our hearts are used to pumping blood up to our brains against the pull of gravity. Gravity also helps blood flow down to our limbs and the rest of our body. The reduction of gravitational force in space disrupts this normal pattern. The disruption of this process affects the brain, eyes, skeleton, and every other organ system in the human body.

Space and the Musculoskeletal System

Gravity is what makes moving on planet Earth work. When you go for a run, you are battling the pull of gravity with every step. If you are in space, your body is no longer working so hard to move. As astronauts float around in space, their bones and muscles are also not feeling any impact. This may sound great for a little while, but in the long term, this can be hard on the human body. Eventually, an astronaut's body decides it no longer needs to build bones. Therefore, the structure of the bones begins to break down, or demineralize. In fact, astronauts can lose up to 2.5 percent of bone matter every month that they are in space. Since an astronaut's muscles are not asked to work against gravity in the same way, the muscles also begin to lose mass, or atrophy. To combat these negative effects on the musculoskeletal system, astronauts must exercise for two and a half hours per day.

The Human Body without Gravity, *continued*

Now that you have learned about some of the physical challenges of life in microgravity, begin thinking about a product that could help minimize the negative effects of space travel on astronauts. Who knows, someday you may go to space and need your own support system that you have designed.

Sketch your plan for your product to help astronauts.

Think About the Activity

- **How does spending time in space affect the body system you chose?**
- **What materials did you choose to create your product, and why did you choose them?**
- **What system(s) are found in the product you designed?**
- **How will your product minimize the health risks to future astronauts as they travel to space?**

Exercise: Unit 1

Name ______________________________ **Date** ________________

Instructions

Question 2: Please answer each question carefully.

1. Which of the following is a list of components of the body system in order from least complex to most complex?

A. tissue, cell, organ, body system.
B. cell, tissue, organ, body system.
C. body system, organ, cell, tissue.
D. organ, tissue, cell, body system.

2. Nutrients and oxygen enter cells through the

A. cell membrane
B. mitochondria
C. ribosomes
D.nucleus

3. Which of the following structures is found in both plant and animal cells?

A. cell membrane.
B. cell wall.
C. arge, water-filled vacuole.
D. chloroplast.

4. The control center of the cell and is responsible for cell division..................

A. mitochondria.
B. nucleus.
C. golgi apparatus.
D. chloroplast.

5. Which of the following is found in an acacia plant leaf and is not found in human?

A. Cell wall.
B. Mitochondria.
C. Cell membrane.
D. Cytoplasm.

6. When two muscles work together to carry out a movement, one muscle............ while the other....................

A. moves, stays still.
B. contracts, relaxes.
C. stays still, relaxes.
D. stays still, contracts.

7. Which of the following muscles is voluntary?

A. Stomach muscles.
B. The muscles of the small intestine.
C. The muscles of the esophagus.
D. Neck muscles.

8. The The human body uses which selection of organs to move gases in and out of the body?

A. heart, veins, and arteries.
B. nose, trachea, and lungs.
C. muscles and bones.
D. pancreas, gall bladder, and thyroid gland.

Exercise: Unit 1

Name ______________________ **Date** ______________

9. In Which systems are involved in the process of excretion?

A. respiratory, circulatory, and digestive
B. urinary, skin, and respiratory
C. circulatory, skin, and nervous
D. nervous, respiratory, and digestive

10. What are nephrons?

A. vessels for holding urine before it leaves the body
B. the place where urine leaves the body
C. organs that break food into smaller parts
D. Microscopic filters that remove harmful substances from

11. Diabetes is a disorder of the endocrine system. In people with diabetes, the......... does not produce enough insulin?

A. gall bladder
B. thyroid gland
C. pancreas
D. small intestine

12. The factors on which gravitational force depends are..................?

A. mass and shape.
B. Size and shape.
C. mass and volume.
D. distance and mass.

13. The electrical insulating materials.......................

A. Rubber
B. Iron.
C. Copper.
D. Aluminum.

14. When a piece of wood is replaced by a piece of aluminum in an electrical circuit, this causes ....

A. Current flow.
B. Open the circuit.
C. Close the circuit.
D. Lighting the lamp.

15. From the conditions for lighting a lamp in an electrical circuit is ....

A. The presence of a battery in the circuit.
B. The key is on.
C. There is no insulating material in the circuit path.
D. All the above.

16. Which lamps light up only when switch (p) is closed in the following electrical circuit?

A. 3 – 4.
B. 1 – 3 –4.
C. 1 – 2.
D. 1 – 2 – 3.

E
2
1
4
P
3

Exercise: Unit 1

Name ____________________ **Date** ____________

Question 2: Complete using the following word bank:

(cell membrane - organelles - organs - cell wall - circulatory system - digestive system - kidneys – bladder)

1. Surrounds some cells membrane..................
2. The small structures inside the cell are called ....
3. The system in the human body consists of a group of ....
4. The .... allows water to enter and exit cells to maintain water balance on both sides.
5. The heart beats in the.................. system accelerates when feeling afraid.
6. The .... in the urinary system purify the blood.

Question 3: Write the scientific term for each of the following:

1. A group of organs that work together to perform a specific function. (.....................)
2. A device used to examine very small things. (.....................)
3. The pattern formed by iron filings near the magnet. (.....................)
4. A system that secretes hormones stimulating the rest of the body's systems to respond. (.....................)
5. Small electric charges moving in the wires in a closed electrical circuit. (.....................)

Exercise: Unit 1

Name ______________________ **Date** ______________

Question 4: Put (✓) or (X) in front of the following statements:

1. All cells are formed of organelles, each of which performs a different function. ( )
2. Tissue consists of a group of similar cells. ( )
3. Water and wastes are stored in the vacuole. ( )
4. Plant cells and animal cells are completely similar in structure. ( )
5. All living cells contain chloroplasts. ( )
6. The brain does not respond when feeling stressed. ( )
7. Every system in the body works individually when exposed to danger. ( )
8. Sweat is excreted by the lungs. ( )
9. The skin takes part in expelling sweat through the pores. ( )
10. The muscles of the body work together at the same time. ( )
11. A human can control the movement of blood in his body. ( )
12. Muscle cells are short fibers that allow movement, storage and release of energy. ( )

Question5 : Match the phrases in column (A) with the appropriate ones in column (B

(A)	(B)
1. Excretory system.	( ) releases hormones into the body
2. Endocrine system	( ) cleans the blood and excretes the body wastes.
3. Musculoskeletal system	( ) tissues contract and allow for body movement.
	( ) it transports gases through the blood vessels

Unit 2
Getting Energy

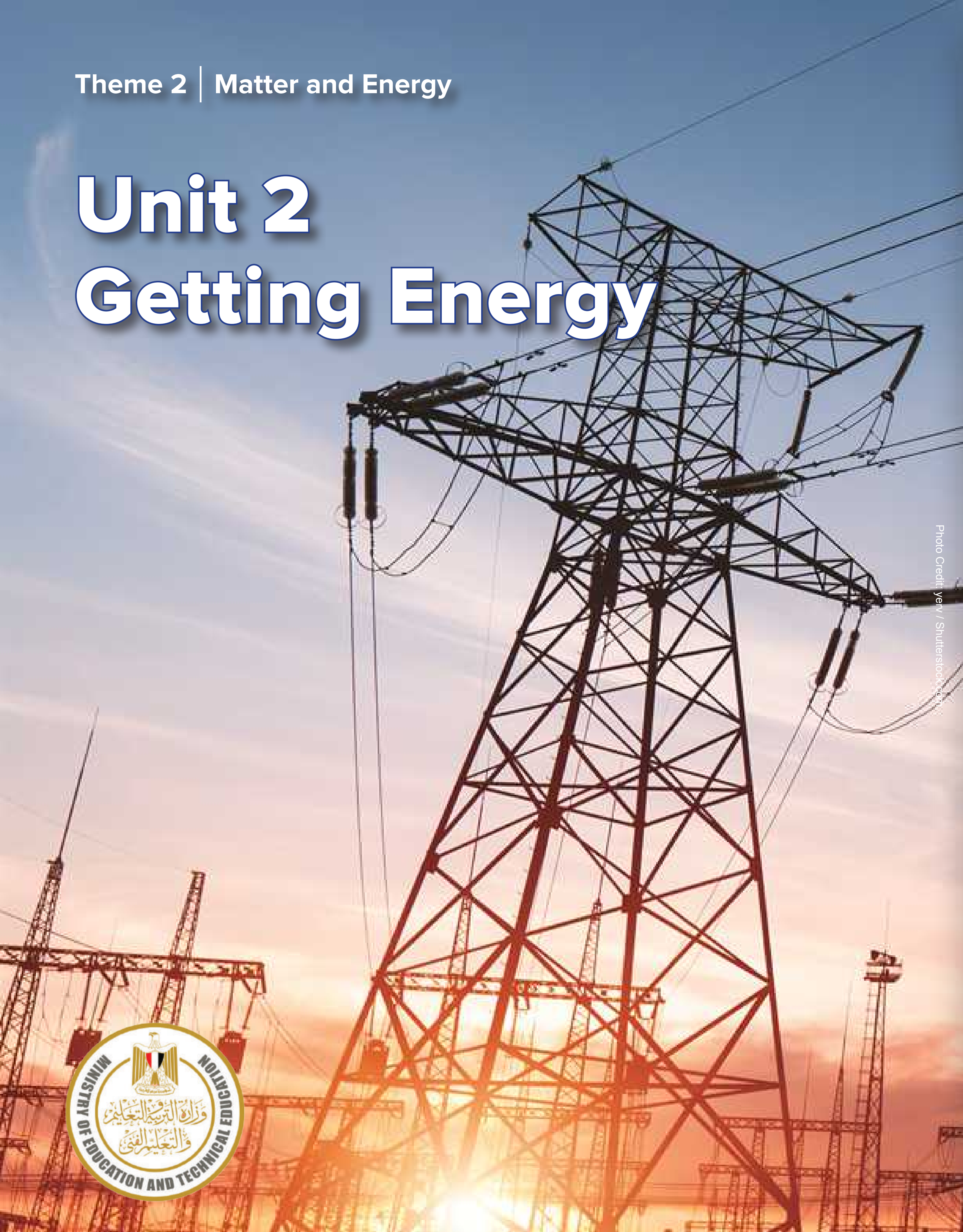
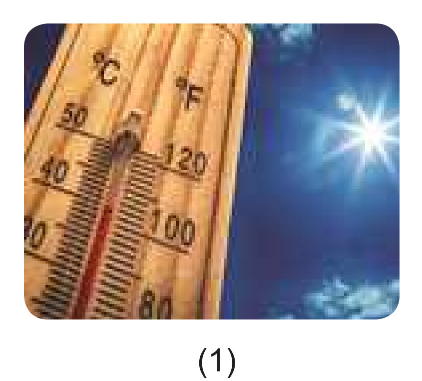


Photo Credit: yelv / Shutterstock.com

What I Already Know


Quick Code: egs6074

In this unit, you will learn more about heat and energy transfer. When you look at the images shown, consider what you already know about how temperature, energy, and innovation go together. For example, you can see a thermometer in image 1. Is the measurement showing a hot or cold temperature? How do you know? In image 2, image, the woman is wearing an oven mitt. Why? Have you ever used a mitt or a rag when cooking? What would happen if she grabbed the tray without such protection? In image 3, the woman is selecting clothing and using technology. What might she be looking at that could help determine what type of clothing she will choose? Do you choose different clothing for different situations? How does heat or temperature factor into your choices?



(1)


(2)


(3)

As you think about the images shown, **write what you already know about temperature, heat transfer, and how different fabrics or materials can protect people or make them more comfortable.**

Talk Together Imagine the different kinds of apps that the woman in the clothing store could be using. Brainstorm how technology can help us make decisions about clothing or activities. Have you ever used an app or other form of technology to help you make a decision? Could technology actually help in making new fabrics?

Packing Lunch for a Trip

Hanny is going on a trip. Since she will be traveling for many hours, she wants to take some food with her. She decides to pack some salad and soup. How can she keep her juice cold and her soup warm? Watch the video, then consider the questions about heat transfer and materials that may be used for transporting food. At the end of this unit, you will be able to explain how energy transfer and innovation can help stop world hunger.



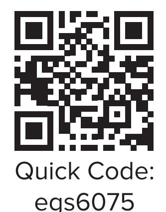

Lunch for Hanny's Trip

How does heat move through substances? What materials can encourage or prevent heat transfer? How do scientists create new materials for better heat transfer or insulation?

Photo Credit: (a) yerv / Shutterstock.com, (b) Duet PandG / Shutterstock.com, (c) superschwarz / Shutterstock.com



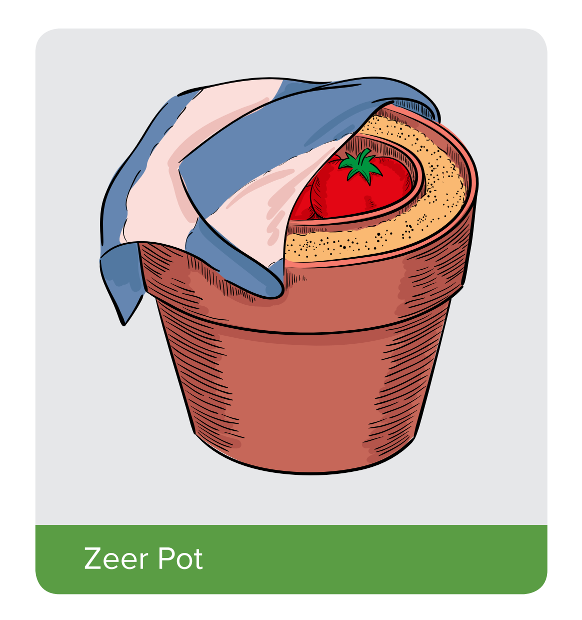
Solve Problems Like a Scientist



Quick Code: egs6075

Unit Project: Zeer Pot Cooling

In this activity, you will use what you have learned about heat transfer and conductivity of materials to investigate a system that prevents food spoilage without the use of electricity or access to modern devices.



Zeer Pot

Ask Questions About the Problem

Think about what you know about how heat can be transferred from one object to another. Consider what types of materials conduct and insulate heat effectively. What materials would you choose if you were going to design a cooling system that would not require the use of electricity nor take up very much space. Write some questions you can ask to learn more about matter, heat, and conductivity. As you learn more about how materials interact with heat and the innovations that can help keep matter cool, record the answers to your questions.

How could a portable cooling system be designed to preserve food and prevent spoilage?

Life Skills **I can carry out solutions and evaluate results.**

CONCEPT
2.1

Thermal Energy and States of Matter

Student Objectives

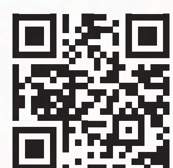
By the end of this concept:

- ☐ I can explain patterns in the movement of particles in solids, liquids, and gases.
- ☐ I can argue from evidence how the effect of increasing or decreasing The temperarture on the movement of particles and the state of matter.
- ☐ I can explain relationships among temperature, heat, and thermal energy.
- ☐ I can model the relationship between kinetic energy of particles and temperature.
- ☐ I can conduct an investigation to determine the effect of changing temperature on particle movement in a thermometer.

Photo Credit: Alexey Stiop / Shutterstock.com

Key Vocabulary

- ☐ atom
- ☐ condensation
- ☐ contraction
- ☐ expansion
- ☐ heat
- ☐ kinetic energy
- ☐ matter
- ☐ molecule
- ☐ temperature
- ☐ thermal energy



Quick Code:
egs6077



Activity 1

Can You Explain?



Thermal Energy and States of Matter



Look at the thermal pool in the photo. Can you observe **matter** changing state? Can you predict what is causing this change? Substances around us often change from one state to another. **Thermal energy**, **heat transfer**, and **temperature** are involved in these changes. Can you think of some examples of ways that matter changes state? What happens to the particles when changes in matter occur?

How are changes in thermal energy, heat transfer, and temperature related to particles in matter?

....

....

....

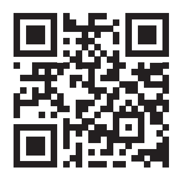


Quick Code:
egs6080

Photo Credit: (a) Alexey Stiop / Shutterstock.com, (b) Niwat panket / Shutterstock.com

Activity 2

Ask Questions Like a Scientist



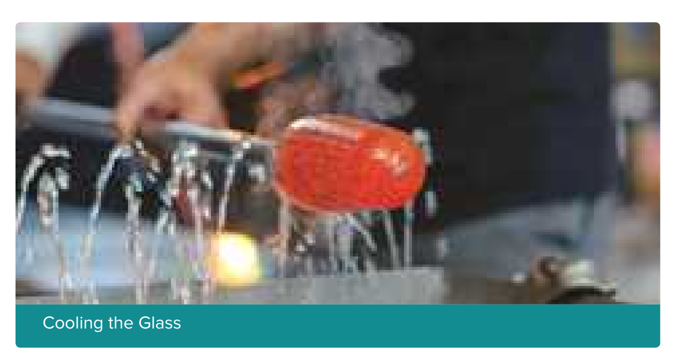
Quick Code: egs6081

Glassblowing

Have you ever wondered how people shape glass? A long time ago, people discovered that glass could be blown from the open end of a hollow tube and turned into all sorts of different shapes using very high heat. Look at the two photos. Brainstorm questions about thermal energy in states of matter with your partner. Some questions are open-ended, meaning they have lots of ways to be answered. Some questions are simple and can be answered with a *yes* or *no* response. Think about how to make your questions open-ended.



Glassware Produced on High Fire



Cooling the Glass

What do you wonder about these images? Think about thermal energy in states of matter. **Write three questions you have and share them with the class.**

I wonder . . .

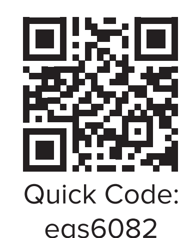
Once you have recorded your Wonder statements, share your questions with a partner. **Feel free to add any new questions that come up in your discussion to your list.**

Photo Credit: (a) Alexey Stiop / Shutterstock.com (b) Peter Kai / Shutterstock.com (c) Cozine / Shutterstock.com (d) Tob1900 / Shutterstock.com



Activity 3

Evaluate Like a Scientist



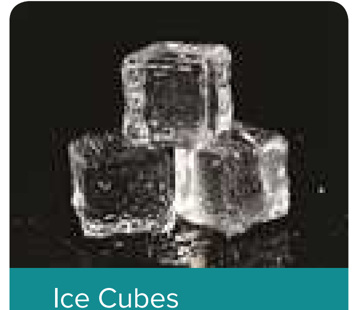
Quick Code:
egs6082

What Do You Already Know About Thermal Energy in States of Matter?

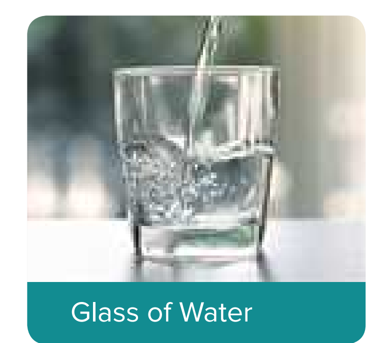
Energy of Particles

Almost all matter contains thermal energy. Thermal energy is the movement of particles within an object. The transfer of this energy is called heat. Each of the following images shows water in a different state. Previously, you learned how particles in different states of matter behave. Use what you know to predict how much thermal energy each of these items contains. **Use the word bank to label each picture with the correct amount of thermal energy.**

least energy	moderate energy	most energy



Ice Cubes



Glass of Water



Boiling Water

Explain why you labeled the images the way you did.

Solids, liquids, and gases are characterized by spatial arrangement and the speed of atoms and molecules. Each state of matter can also be identified by whether it has a fixed or variable volume and a fixed or variable shape.

Summarize these characteristics by selecting the correct word from the word bank for each sentence. Some words may be used more than once.

fixed	variable	high	low

1. The molecules within a solid are very close together and vibrate in a __________ position.
2. Substances in the solid state have a fixed volume and shape. Liquids have a fixed volume ____________ shape.
3. Gas molecules are in constant motion at ____________ speed and therefore they are spaced far apart.
4. Gases have a ____________ shape and volume. They can float freely or be compressed under pressure.

Activity 4

Observe Like a Scientist

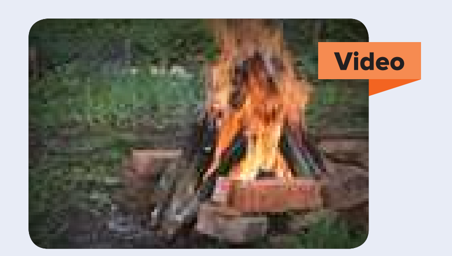




Quick Code:
egs6085

Thermal Energy, Heat transfer, and Temperature

What is happening to matter when we say something is hot or cold? What is the difference between thermal energy, heat transfer, and temperature? Read the text, watch the videos, and listen for the meaning of these terms. Record your ideas and share with a partner.



Previously, you learned that **kinetic energy** is the energy of motion. The thermal energy of a substance relates to the total sum of the kinetic energy of the substance's atoms and molecules. Since the molecules in a solid are not moving as fast as in a liquid, a solid has less thermal energy than a liquid. Thermal energy is a property of a system. For example, you could talk about the amount of thermal energy in a cup of hot tea.



We often describe the warmth of an object by saying that it contains heat. However, scientifically speaking, Temperature is a measure of average of the kinetic energy of particles in any substance . If you hold an ice cube in your hand, your body temperature has more energy and causes the ice cube to melt. The three different types of heat transfer are conduction, convection, and radiation. You will learn more about these in later studies.

Use what you learned from the text and videos to write a definition of each term.

	Notes
Thermal Energy	
Heat	
Temperature	



Activity 5

Observe Like a Scientist



Quick Code:
egs6086

Change of State of Matter

You have seen how water becomes ice when you put it in the freezer, but do you know why? The physical state of a substance is related to its thermal energy. Thermal energy causes molecules to move around and bump into one another. Remember that kinetic energy is the energy of motion. Objects with more thermal energy have more kinetic energy. How much thermal and kinetic energy exists in an object depends on the speed of its molecules. When the temperature of a substance increases, so does the speed of the molecules. A decrease in temperature also means a decrease in molecule speed. Complete the interactive to experiment with substances at different temperatures and learn more about how they change states.



At certain temperatures, adding or removing thermal energy will cause matter to change from one state to another. As a solid is heated, its particles vibrate faster and faster and move farther apart. Eventually their energy is great enough to overcome the forces that hold them in place. Melting occurs, which is the change from solid to liquid. A similar process occurs when the liquid is heated. Eventually the particles have enough energy to escape their attractive forces, and the liquid vaporizes into a gas.

Cooling a sample of matter, which involves the removal of thermal energy, causes the opposite change of state. **Condensation** is the change from gas to liquid. Freezing is the change from liquid to solid. In a solid, the particles are packed tightly and vibrate instead of moving around freely.

Substances boil or melt at specific temperatures. The melting points and boiling points are characteristic physical properties of a substance. For example, ice has a melting point of zero degree(0°C), water has a boiling point of 100°C, and mercury has a boiling point of 357°C.

Life Skills **I can anticipate and summarize outcomes.**

Create diagrams to model what happens to molecules during a change of state.

	Before Interactive	After Interactive
Solid to Liquid		
Liquid to Gas		
Gas to Liquid		
Liquid to Solid		

- **Describe the change of state at freezing point. What was the effect on the molecules?**
- **Which substance had the lowest boiling point?**
- **What was the change of state at boiling point? How did the molecules react?**



Activity 6

Investigate Like a Scientist





Quick Code:
egs6088

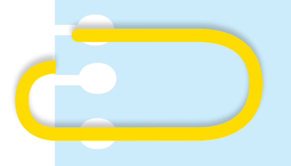
Hands-On Investigation: Temperature and Particle Movement

It is easy to tell the difference between hot and cold water by touching it. Do you know that hot and cold water also behave in different ways? In this investigation, you will carry out an experiment to compare how quickly food coloring will spread out in hot and cold water.

Make a Prediction

How will temperature affect the kinetic energy and motion of particles? Record your predictions in the table.

If temperature . . .	The kinetic energy of the particles will . . .	And the velocity of the particles will . . .
increases		
decreases		
no change		



What materials do you need? (per group)

- Safety goggles (per student)
- Heat mitts
- Beakers, 250 mL, 2
- Thermometers, 2
- Hot water, 35 to 45°C
- Cold water, 2 to 8°C
- Stopwatches, 2
- Food coloring (blue, red, or green suggested)
- Eyedroppers, 2

HANDS-ON INVESTIGATION



I can anticipate and summarize outcomes.

Photo Credit: (Alexey Stiop / Shutterstock.com

What Will You Do?

1. Add 100 milliliters (mL) hot water to one beaker and 100 mL cold water to the other beaker.
2. Place a thermometer into each beaker and record the temperature of the water in the data table.
3. Using the two eyedroppers, add two drops of food coloring to the center of each beaker at the same time.
4. Start the stopwatches at the instant the food coloring is added to the two beakers. Time the hot-water beaker with one watch and the cold-water beaker with the other watch.
5. Observe how long it takes for the drops of food coloring to completely spread out and form a uniform solution in each beaker. Be careful not to stir the water in either beaker with the thermometers or shake the beakers by picking them up.
6. Record your data and observations.
7. Repeat steps 1 to 6 using 200 mL of water.

Trial 1: 100 mL water + 2 drops of food coloring

	Temperature	Time for Food Coloring to Spread Out	Observations
Hot Water			
Cold Water			

Trial 2: 200 mL water + 4 drops of food coloring

	Temperature	Time for Food Coloring to Spread Out	Observations
Hot Water			
Cold Water			

Think About the Activity

- **What pattern do you observe in your data?**
- **Use the terms kinetic energy, thermal energy, and temperature to explain what happened in your experiment.**

Activity 7

Evaluate Like a Scientist





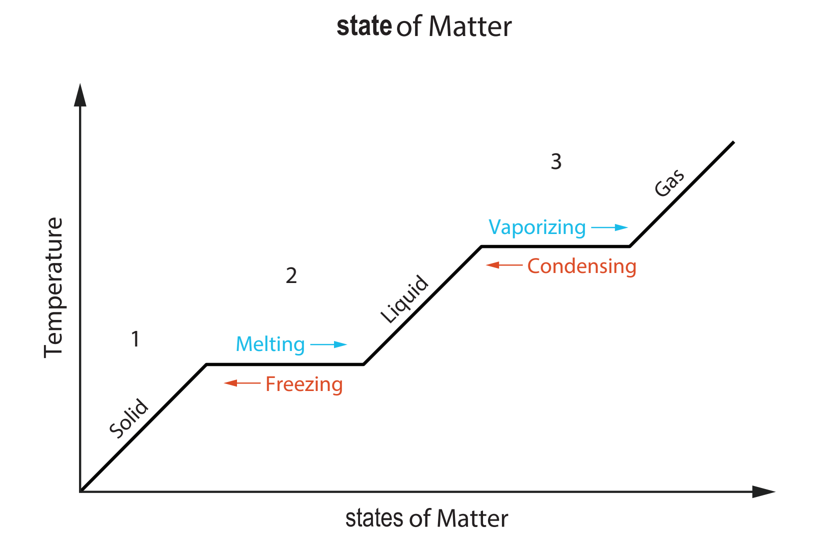
Quick Code:
egs6090

Thermal Energy and Particle Movement

Changing States

Why does matter not stay in one state? How does ice cream freeze? What causes ice cream to melt back into a liquid? Read about the following changes of state. Think about what is happening in the context of what you have learned about thermal energy and changing states.

A beaker of ice was heated at constant temperature until the ice completely melted, boiled, and then evaporated. The temperature of the water was recorded at regular intervals. This information is represented on the following graph. The statements below the graph describe this process. **Complete the statements by filling in the blanks with the correct information.**



kinetic energy	boiling point	melting point	heat energy

1. At first, the ______________________________ absorbed by water molecules when the beaker is heated is changed to ______________________________.

2. Matter changes from a solid state to a liquid state at ______________________________.

3. With enough heat, the forces become so weak, and the molecules spread so far apart, that the liquid water becomes a gas or water vapor. This is called the ______________________________.

Activity 8

Observe Like a Scientist

Quick Code: egs6091

Thermal Expansion

Have you ever tried to kick a rubber ball on a cold day? If you have, you know that when the temperature drops, a ball can sometimes seem to lose air, making it less bouncy. Why does this happen? You know that molecules in matter behave differently when temperature varies. molecules are often packed more tightly together than warm molecules, which tend to spread out. The changes in matter that happen because of the way that molecules are arranged are known as **expansion** and **contraction**. Expansion means the molecules spread out or expand. Contraction means they come together or contract. Can you think of other times that you have seen this happen?

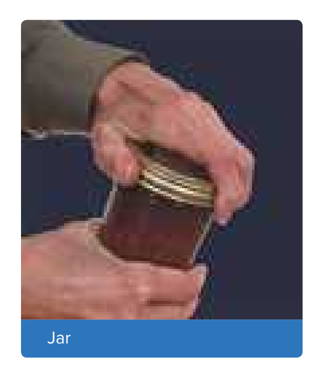
Look at the following images and then discuss with a partner how contraction or expansion is involved in each scenario.

Many thermometers contain alcohol mixed with coloring. What happens when you put a thermometer in substances of different temperatures? Why does this happen?
Use the terms expansion and contraction in your answer.



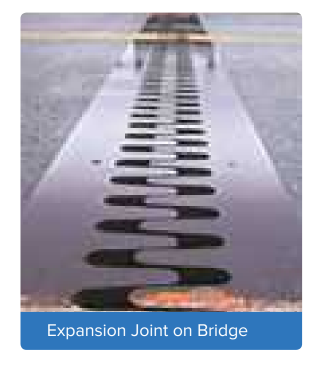
Thermometer in Snow

Sometimes, a jar lid can become stuck. How can holding the lid under hot, running water loosen it?



Jar

Bridges and other structures are often built with expansion joints. Why might expansion joints be necessary?



Expansion Joint on Bridge

Life Skills **I can anticipate and summarize outcomes.**

Activity 9

Investigate Like a Scientist





Quick Code: egs6093

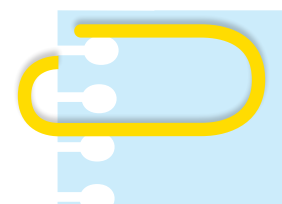
Hands-On Investigation: Making a Thermometer

Liquid thermometers have been used for hundreds of years. In this activity, you will design and construct a thermometer. You will make and test predictions using your model thermometer.

Make a Prediction

Think about what you know about how molecules move when heated or cooled.

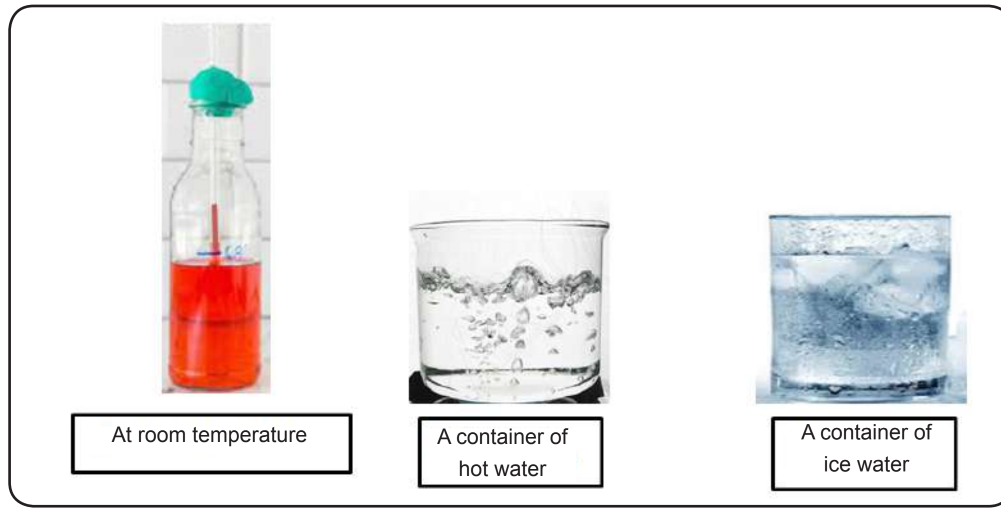
- **What will happen to the water in the straw when the bottle is in the cold water? Record your prediction.**
- **What will happen to the water in the straw when the bottle is in the hot water? Record your prediction.**



What materials do you need? (per group)

- Clay, approximately 3 to 4 cm diameter ball
- Red food coloring
- 70% rubbing alcohol, 50 mL
- Clear plastic straw
- Water, 50 mL
- Plastic water bottle, 500 mL
- Metric ruler
- Safety goggles (per student)
- Bowl of hot water
- Bowl of ice water





Making a Thermometer

Photo Credit: Alexey Stiop / Shutterstock.com

What Will You Do?

1. Pour equal amounts of water and rubbing alcohol into the bottle until the bottle is $\frac{1}{4}$ full.
2. Add three drops of red food coloring.
3. Put the straw in the bottle.
4. Pull the straw up and be sure it is not touching the bottom as you wrap the clay tightly around the straw and the opening of the bottle.
5. Leave the opening of the straw uncovered.
6. Place the bottle flat on a surface. Position a ruler vertically, next to the bottle. Measure and record the height of the water in the straw at room temperature.
7. Place the bottle into a bowl of ice water and measure the height of the water in the straw.
8. Place the bottle into a bowl of hot water and measure the height of the water in the straw.

Results

Record your observations.

	Water Height (cm)
Room Temperature	
Cold Water	
Hot Water	

Think About the Activity

How was thermal expansion and contraction applied to the function of your thermometer? In your response, use the terms *temperature*, *heat transfer*, and *kinetic energy*.



Activity 10

Evaluate Like a Scientist



Quick Code: egs6094

Increasing Thermal Energy

There are many different ways that scientists communicate their scientific explanations. Scientists may use models, diagrams, data charts, graphs, written text, and oral presentations.

Scientists share their findings so that people can build upon each other's ideas. Once you have completed your scientific explanation, share it with your classmates.

Adding Thermal Energy

The statements below describe what happens when thermal energy is added to a substance. **Complete each statement with the missing key word.** Some words may be used more than once or not at all.

increase	rise	expand
decrease	faster	

1. The particles in a substance will move ____________________ when thermal energy is added.
2. The kinetic energy of a substance will ____________________ when thermal energy is added.
3. The temperature of a substance will ____________________ when thermal energy is added.
4. The substance will ____________________ when thermal energy is added.
5. The space between particles will ____________________ when thermal energy is added.

Scientific Explanations

Think about how particles in matter can change when a substance becomes hotter, cools down, or changes state. As a scientist, select the best way to communicate your explanation. You may also use a combination of these methods.

- **Present your explanation using an oral communication method, such as a video of yourself, a conversation with another student, a skit, or an audio file.**
- **Represent your explanation using a model (physical or diagram).**
- **Present your explanation in a creative written form.**

Activity 11

Record Evidence Like a Scientist





Quick Code:
egs6096

Circle Back: Thermal Energy and States of Matter

Now that you have learned about thermal energy and states of matter, look again at Glassblowing. You first saw this in Wonder.


Glassware Produced on High Fire


Cooling the Glass

How can you describe Glassblowing now?

How is your explanation different from before?

Look at the Can You Explain? question. You first read this question at the beginning of the concept.



Can You Explain?

How are changes in thermal energy, heat, and temperature related to particles in matter?

Now you will use your new ideas about Glassblowing to defend a claim using evidence. First, write your claim. A claim is a one-sentence answer to the question you investigated. It answers, What can you conclude? It should not start with *yes* or *no*.

Record your claim.

Next, write a scientific explanation with evidence that supports your claim. Evidence can come from videos, readings, interactives, and Hands-On Investigations.

Record your evidence-based scientific explanation.

Choose one additional idea that you would like to research. **What would you do to learn more? What resources would you use to extend your research? How would you build upon your investigations?**

Record your research, and the resources you used.

Life Skills **I can apply an idea in an innovative way.**



STEM in Action



Quick Code: egs6097



Activity 12

Analyze Like a Scientist

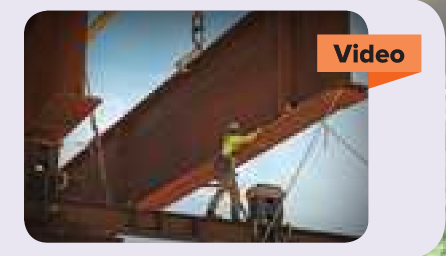
Thermal Expansion Joints



Thermal Expansion Joints

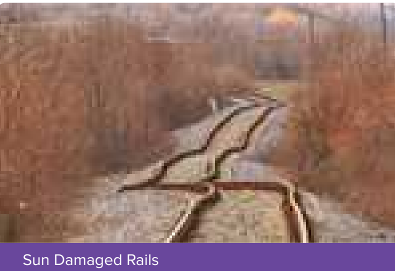
This bridge does not have a zipper, and it does not have jaws with metal teeth. Instead, it has built-in protection designed to keep the bridge from buckling in hot weather and cracking in cold weather. You saw this image previously, when you learned about how thermometers work. Apply what you know about how thermometers function as you now learn how engineers apply the same principles of expansion and contraction when designing structures. Expansion joints are an important engineering design feature of bridges, sidewalks, and railroad tracks. How else do engineers protect bridge from the effects of heat?

Most bridges are made of steel and concrete. When these materials are exposed to hot and cold temperatures, they expand and contract. Engineers use a variety of techniques when designing bridges to make sure bridges stay safe over time.



Video

Is Enough Room Left for Expansion?

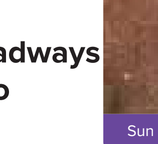


Sun Damaged Rails

Increased average temperatures result in greater expansion of roads and railways.

Research the occurrence of the failure of expansion joints in roadways or train tracks (often referred to as sun kinks). Include images to illustrate the problem.

- **How common is it?**
- **What other problems does it cause?**
- **What can be done to solve the problem?**
- **If researching sun kinks is not possible, brainstorm a list of structures that might be affected by changes in temperature. Include how the integrity of these structures could be affected if safety measures are not put in place.**



Unit Project Connections: Thermal Energy and States of Matter

How does the information that you have learned about thermal energy, heat, and temperature connect with the Unit Project, Zeer Pot Cooling. What research and resources will you need to complete the Unit Project?

CONCEPT 2.2

Heat Transfer

Student Objectives

By the end of this concept:

- [ ] I can define the ways that thermal energy is transferred.
- [ ] I can analyze and interpret data to explain that mass is conserved during the transfer of thermal energy.
- [ ] I can construct a model and use it to investigate various materials to determine their ability to conduct and insulate heat.

Photo Credit: Bmphotographer / Shutterstock.com

Key Vocabulary

- [ ] calories
- [ ] heat conductor
- [ ] conduction
- [ ] conductor
- [ ] convection
- [ ] heat transfer
- [ ] insulate
- [ ] insulator
- [ ] Law of Conservation of Mass
- [ ] thermal equilibrium
- [ ] radiation



Quick Code: egs6100



Activity 1

Can You Explain?
Heat Transfer





Look at the lizard on the rock in this photo. The rock has been warming in the summer sun. Have you ever felt a rock or a piece of playground equipment in the middle of a summer day? What do you think the rock will feel like to the lizard? Can you observe any examples of **heat transfer**? What is releasing thermal energy? What is absorbing thermal energy? Imagine that you could see the molecules inside the rock. How would these molecules change when heated by the sun?

What happens to an object when heat is transferred?

____

____

____



Quick Code:
egs6103



Activity 2

Ask Questions Like a Scientist



Quick Code: egs6104

Ironing

Have you ever wondered why the handle of an iron is plastic and not metal? Some materials are resistant to the transfer of heat energy. These materials are called **insulators**. Metals, on the hand, are good thermal **conductors**. What would happen if the iron handle was made of metal?

Heat from the iron interacts with the shirt to smooth out any wrinkles. With your partner, talk about what you observe in the image. Brainstorm questions about interactions with heat. Some questions are open-ended, meaning they have lots of ways to be answered. Some questions are simple and can be answered with a *yes* or *no* response. Think about how to make your questions open-ended.

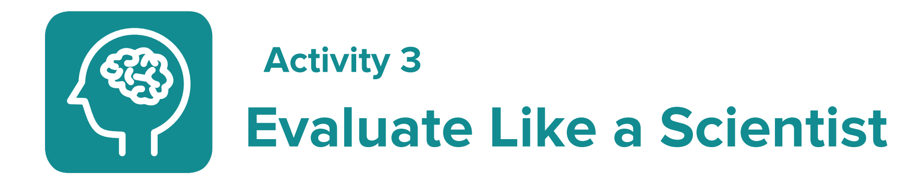


Iron Made of Metal and Plastic

What do you wonder about these images? Think about interactions with heat.
Write three questions you have and share them with the class.

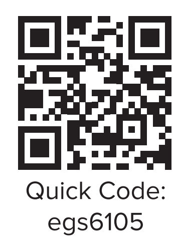
I wonder . . .

Once you have recorded your Wonder statements, share them with a partner. Add any new questions that come up in your discussion to your list.



Activity 3

Evaluate Like a Scientist



Quick Code: egs6105

What Do You Already Know About Heat transfer ?

Properties of Heat



Blowtorch Melting Metal

You already know some basic information about the transfer of thermal energy, known as heat. **Which statements correctly describe the properties of heat? Select all that apply.**

A. Heat is an essential component of life on Earth.

B. Heat is energy that flows from one object to another.

C. Heat flows from a hotter object to a colder one.

D. The more heat is transferred to an object, the slower its molecules move.

E. Water freezes at 32°C.

F. Heat is a type of matter.

G. Heat cannot be lost, only transferred.

think about the following question

Does an object that feels cold to the touch contain thermal energy? Explain your answer.



Activity 4

Analyze Like a Scientist





Quick Code:
egs6106

What Is Heat?

All matter is composed of vibrating atoms or molecules. The more kinetic energy that is added, the faster the molecules vibrate. You might have a lot of questions about heat. For example, Can all objects transfer heat? Can people make heat? Can heat be shared?

Read the following text and underline information you can use as evidence to support your ideas for the Can You Explain? question. After you finish reading, return to the questions about heat and look for evidence from the text to support your thinking.

What Is Heat?



Gas Stove Burner

Metal can be made warmer by hitting it with a hammer. Soup can be made warmer by putting a flame to it. This movement, or kinetic energy, creates the effect we feel as warmth. Whenever something becomes warmer, the kinetic energy of its atoms or molecules increases. The energy that transfers from one object to another because of temperature difference between them is called heat. Heat is defined as the transfer of thermal energy from a warmer object to a cooler object. Heat is often measured in units called **calorie**.

Photo Credit: Marian Weyo / Shutterstock.com

How Heat Is Transferred

Heat transfer happens when there is a temperature difference between two objects. Heat always flows from a hotter object to a cooler one. So, when your hot dinner sits out on the table and gets cold, heat flows from the hot food to the cooler air around it. It does this until the food and the air nearby are the same temperature. When this happens, the food and the air are said to be at **thermal equilibrium**. Heat never flows from a cool object to a warmer object.

Talk Together After reading, share your ideas with a partner. Ask questions such as: Why do you think that? What is your evidence? How did you arrive at that conclusion?

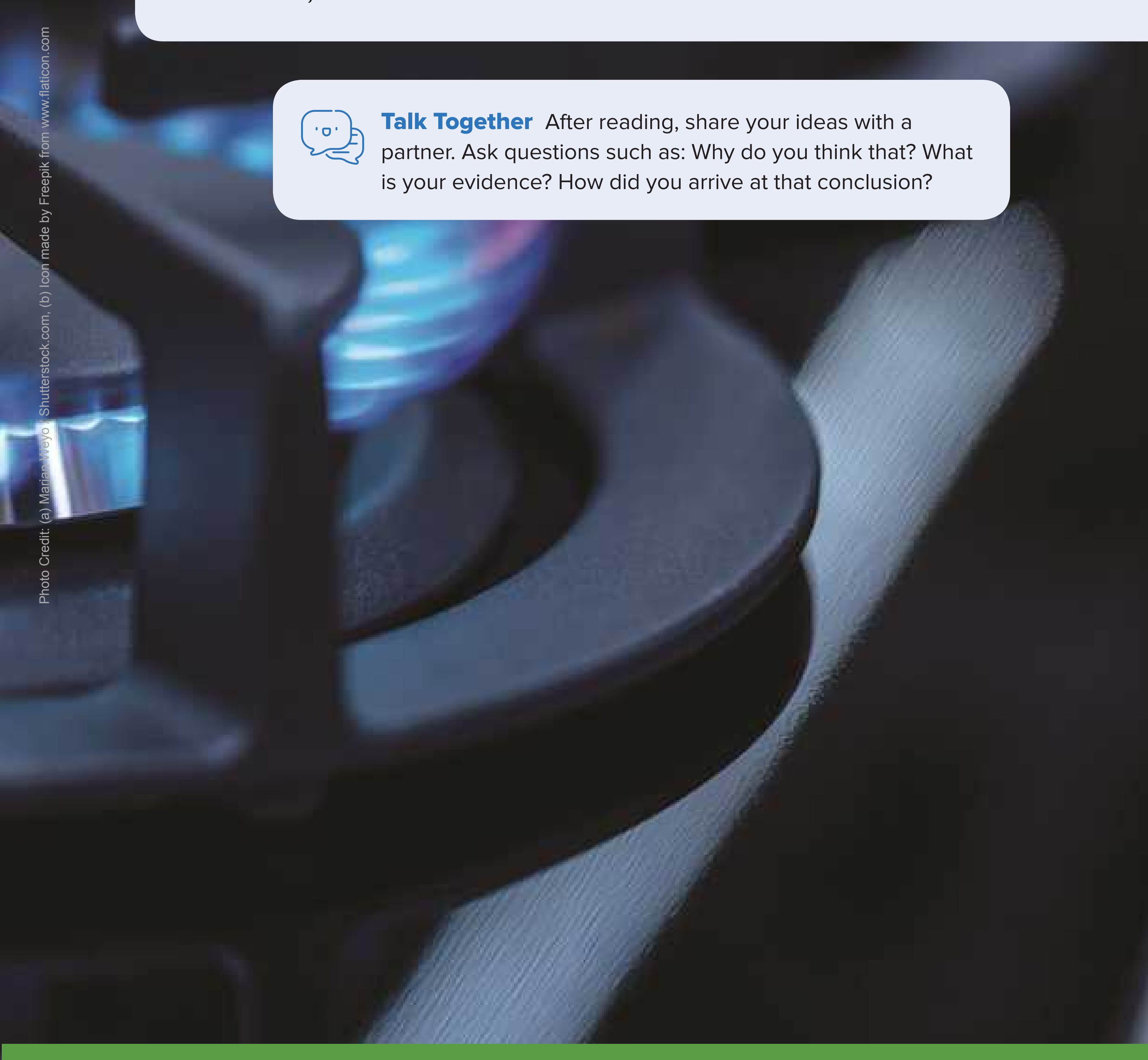


Photo Credit: (a) Marian Weyo / Shutterstock.com, (b) Icon made by Freepik from www.flaticon.com



Activity 5

Investigate Like a Scientist



Quick Code: egs6108

Hands-On Investigation: Final Temperature

Imagine you have fixed a cup of hot tea for your mother. Unfortunately, it is too hot, and you need to add some cold water to cool it off. How much cold water should you add? Is there a way to predict the resulting temperature in advance?

Make a Prediction

Describe what you think will happen to the final temperature of water when you mix hot and cold water.

What happens when hot water is mixed with cold water? Support your answer with an explanation.



What materials do you need? (per group)

- Graduated beakers, 3
- Laboratory thermometer
- Ice
- Water
- Stirring rod or spoon
- Goggles (optional)
- Lab aprons (optional)
- Hot plate (optional)



What Will You Do?

You will use your knowledge of thermal energy in an investigation to explore thermal equilibrium. Thermal energy is the collective energies of kinetic motion of a substance.

1. Place equal amounts of hot water and cold water in two beakers.
2. Record the temperature of each beaker.
3. Calculate and record the average temperature of the two beakers.
4. Combine the water from the two beakers into the third beaker. Use the stirring rod or spoon to gently mix. Be sure the two amounts combined will not overflow the third beaker.
5. Measure the temperature of the third beaker. Record this measurement.
6. Wait 3 minutes and record the final temperature of the water. Record this measurement.
7. Compare the final temperature to the average temperature you calculated earlier.

Life Skills **I can carry out solutions and evaluate results.**

Results

Record your observations.

Temperature of Hot Water	
Temperature of Cold Water	
Average Temperature	

	Immediately after Mixing	After 3 Minutes
Temperature of Mixed Water		

Think About the Activity

Reflect on your results.

- **What do you notice about the data collected?**
- **Is there a pattern between the starting temperatures and the final temperature?**
- **Why might the final temperature be slightly lower than the average temperature?**
- **Based on the results of this experiment, what would you do to fix the cup of tea that is too hot?**

Imagine you could see the molecules in action as the water mixing occurred.
Draw a series of images supported with words that describe the motion of the molecules before, during, and after mixing.

Kinetic Energy		
Hot Water	Cold Water	Mixed Water







Quick Code:
egs6110

Conduction, Convection, and Radiation

When you have a sore muscle, a heating pad can transfer heat to the part of your body that it touches. When you sit outside and the sun shines on your face, your face feels warm. How does this happen? What are some other ways that heat can be transferred? Watch the video and record ways heat can be transferred.



Heat is the transfer of thermal energy from one place to another by **conduction**, **convection**, or **radiation**. Heat energy always flows from a hot substance to a cooler substance. The heat continues to flow until the objects reach the same temperature, or equilibrium. Many things affect the rate at which heat is transferred, including the difference in temperature, surface area, or length of contact.

Conduction occurs with objects that are touching. Some materials, such as metals, help transfer heat. We call these conductors. Some materials, such wood, prevent heat from being transferred. We call these insulators.

Have you ever seen noodles boiling in a pot? The noodles close to the bottom of the pot, near the heat source, get hot and rise to the surface. Then, they cool and sink back to the bottom of the pot. This is the result of convection. Convection is the transfer of heat due to the movement of a liquid or gas.

When you lift your face to the sun and your face feels warm, it is because of radiation. Radiation is how heat travels through space. Holding your hands in front of a fire to warm them is another example of radiation.

Meteorologists must understand convection and radiation to help predict our weather. Engineers use their understanding of conduction when they design new products such as new cookware. If you wanted to design cooler, shadier sidewalks, you would need to know about conduction, convection, and radiation.

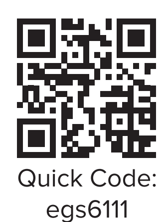
Use the chart to record your ideas about ways heat is transferred. You may include pictures as well as words.

Thermal conduction	Thermal convection	Thermal radiation



Activity 7

Analyze Like a Scientist



Quick Code: egs6111

Thermal Insulation and Conductivity

Different materials transfer heat by conduction at different rates. Sometimes, we want heat to transfer quickly, like when we rub our hands together to warm them up. Other times, we want heat to transfer slowly, like when we want to take some hot tea to a friend. Read the passage and record your ideas in the graphic organizer.

Conductor or Insulator?

Imagine pouring hot soup into two different containers: a metal bowl and a plastic one. Then you touch the outside of each bowl. You would notice that the metal bowl was hot, while the plastic one was just warm. That is because some materials allow heat transfer to occur more easily. These materials **conduct** the heat. Materials that allow heat to travel freely through them are called conductors. Metals, such as copper, and iron, are generally good conductors.



Thermos with Hot Tea

Materials that are poor conductors are called insulators. Even materials that **insulate** well cannot prevent some heat transfer. Insulators only slow down the heat transfer. Examples of insulators are air, plastic, wood, and glass.

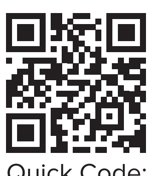
You may have noticed that some objects feel cool when you touch them, even though they are really at room temperature. A metal doorknob may feel cooler than the wooden door it is on. This is because your body is always generating thermal energy, which is transferred away from your skin by good conductors such as metal, but not as well by wood. So, one feels cooler than the other, even though they are both the same temperature.

Draw a diagram of conductors and insulators, giving examples of each.

Activity 8

Observe Like a Scientist





Quick Code:
egs6113

Heat Transfer in the Different Materials

Heat energy is almost constantly on the move. When we think of materials that are used in the kitchen, metal is one of the first ones to come to mind. Metal conducts heat better compared to many other materials. Sometimes, you do not want to touch something hot in the kitchen. For example, you would not want to pick up a hot pot with a metal handle. It could burn you. Therefore, we use other materials for the handle. A handle must provide the user with comfort and safety. Since heat can travel along the handle, the length of the handle is also important. If we place three temperature measuring devices along the length of the handle of a pot, we will see three different temperatures.

use the following results from an experiment designed to test different materials for a pot handle.

	Length of Handle (cm)	Time Heated (min)	Temperature near Pan (°C)	Temperature Middle of Handle (°C)	Temperature End of Handle (°C)
Wood	18	10	60	26	25
Plastic	18	10	54	24	23
Wood	36	10	60	25	24
Plastic	36	10	54	23	22

- **Why is the temperature different at the three measuring points?**
- **Summarize your conclusions and recommendation to Hot Stuff for the best pot handle.**

Activity 9

Analyze Like a Scientist



Quick Code: egs6114

Heat and Conservation of Mass

You already know that heat can be transferred from one object to another. You learned previously that this transfer of heat can lead to changing states of matter. When heat causes change in a substance, is matter ever gained or lost? Read the text below. Use what you learn to answer the questions in the scenarios that follow.

Where Did It Go?

You boil a pot of water on the stove, and eventually, there is no more water left in the pot. But where did it go? If a liquid is heated to a point that it begins to evaporate, the matter simply changes state. No matter is destroyed.



Pot of Boiling Water

When a substance changes state, the mass of the substance does not change. We call this the **Law of Conservation of Mass**. In this example, the water evaporated into the atmosphere as a gas. The same is true if heat is removed from a substance. For example, if you weigh an ice cube and then heat it, the liquid that is left should have the same mass as the ice cube.

Think of a set of building blocks. You build a pyramid out of the blocks and measure its mass. Then, you measure the mass of each individual block in the pyramid. If you add up all those individual masses, you will get the total mass of the pyramid. This idea is important because it supports the scientific conclusions that matter cannot be created or destroyed—just rearranged.

To help you understand the Law of Conservation of Mass, your teacher may have carried out a demonstration using a chocolate bar. Think about what you learned about the mass of the chocolate bar before and after it melted. Did your findings support the information in the text above? Consider the following scenarios. Apply the Law of Conservation of Mass as you answer the questions.

A student decides to make ice pops by placing some juice in a plastic cup into the freezer. If the student freezes 44 g of juice, what will the mass of the student's juice pop be once it is frozen?

A popcorn seller has 100 g of popcorn kernels. The kernels have a small amount of moisture in them. When the seller heats the kernels in oil, they pop, and he can see steam rising. When he weighs the popped corn, it weighs 97 g. The popped corn does not weigh the same as the kernels. Why not?

A teacher has a beaker of water with an ice cube in it. If she weighs this beaker with the water and ice, do you think the combined mass will change as the ice melts? Why or why not?



Activity 10

Investigate Like a Scientist





Quick Code: egs6134

Hands-On Investigation: Design a Marble Run

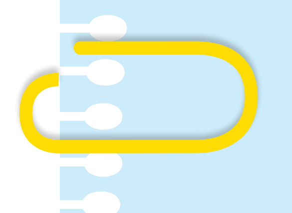
You know that thermal energy can be transferred from one object to another. How else can energy change? Think of a time that you have race down a playground slide. Where did you have the most potential energy? Where did you have kinetic energy? What if there was another bump or hill? Would you have enough energy to get over it?

Now look at this image of a racetrack designed for motorbikes.



Motorbike Racetrack

How is this similar to a playground slide? How is it different? In this investigation, you will create a track with parts like a slide or a bike racecourse for a marble to run down.



What materials do you need? (per group)

- Marble
- Paper
- Scissors
- Tape
- Ruler
- Pencil
- Cardboard (for base)



Make a Prediction

Think about making a track with hills, curves, and loops for a marble to travel down.

How long can you make your track before your marble stops?

Life Skills **I can carry our solutions and evaluate results.**

What Will You Do?

1. Draw a design for your track. Label the locations of potential and kinetic energy.
2. Share your design with your group members. Work together to decide on a final design for one track you will build together.
3. Practice building individual track segments.

   A. To build a loop or hill:

      i. Cut a 7.5 cm wide strip of paper.

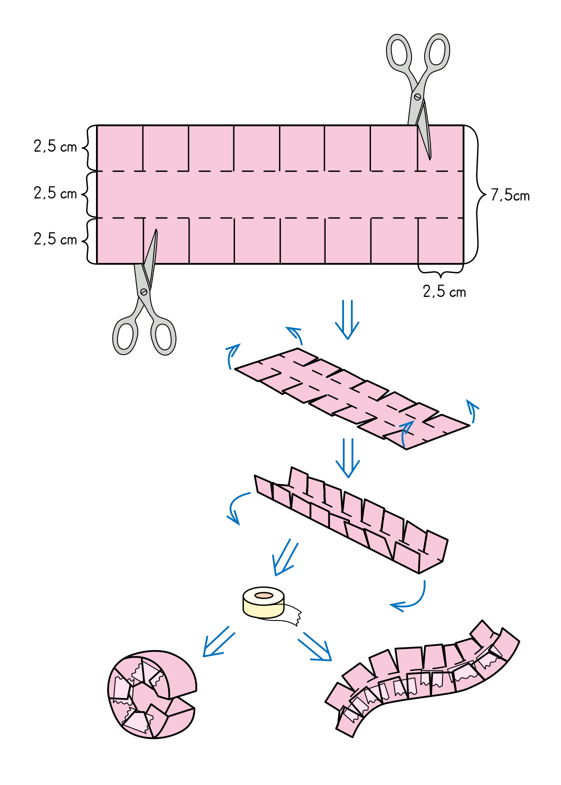
      ii. Draw two parallel lines that divide it into three 2.5 cm wide strips.

      iii. Make marks every 2.5 cm along the long edges of the paper.

      iv. Cut 2.5 cm toward the center from these marks to make tabs.

      v. Fold the tabs up 90 degrees.

      vi. Bend the track into the shape you want and tape the tabs together to hold it in place. You may need to work together to hold the tabs in place while someone else adds the tape.



   A. To build a curve:

      i. Cut a 7.5 cm wide strip of paper.

      ii. Draw two parallel lines that divide it into three 2.5 cm wide strips.

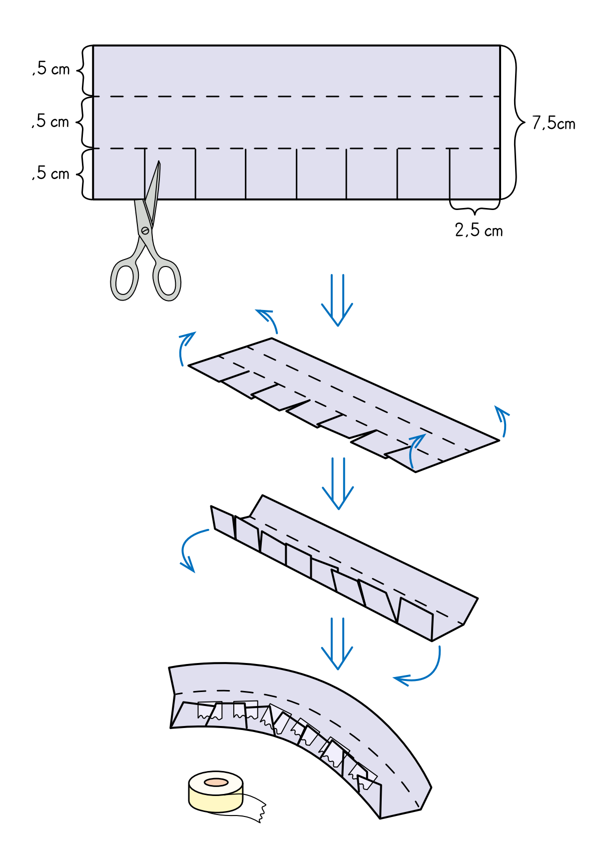
      iii. Make marks every 2.5 cm along the long edges of the paper.

      iv. Cut 5 cm toward the center from these marks.

      v. Fold up the uncut side of the paper 90 degrees to form a wall.

vi. Fold up the tabs on the other side to form the other wall.

vii. Bend it horizontally to form a curve and tape the tabs together to hold the curve in place.



4. Using a piece of cardboard as a base, put your tracks together according to your plan. Tape the track segments together. Tape the tracks to the base.
5. Place your marble at the top of the track and let it go.

Draw a diagram of your marble track. Label the locations of potential and kinetic energy.

Think About the Activity

Think about the way your marble traveled down the track.

- **Did your marble make it all the way to the end of your track? Why or why not?**
- **Where did your marble have the most potential energy?**
- **What changes would you make to your marble track?**
- **How are potential energy, kinetic energy, and friction related?**
- **What do you think would happen if you used a larger marble? Why?**



Activity 11

Analyze Like a Scientist





Quick Code:
egs6129

Properties of New Materials

Understanding energy transfer is critical when developing new materials for a specific use. Some materials insulate, while other materials conduct heat. Investigating conductivity and other properties of mixtures is an important step in the process of finding the right material to do a job. ,then complete the 3-2-1 strategy (3 important facts - 2 new ideas - an idea you want to know more about)

How Are New Materials Created?

When a new material is created, its properties usually differ from those of the materials used to make it. If the new material is a mixture of other materials, it can have a combination of the properties of its parts. If the new material is the result of a **chemical change**, then its properties will be very different from its original materials. Plastic, for example, is made from chemical changes to some of the compounds in petroleum. While petroleum is a liquid that burns easily, plastic is a tough solid that often resists burning.

Mixing It Together

To make new materials, scientists and engineers often mix various materials together. Mixing materials can produce a new material with useful properties. Steel is a mixture of iron and other elements. It is strong, hard, and lasts a long time. Concrete is made of several kinds of rock and sand that are mixed with water. Concrete is useful because it starts as a liquid and then hardens as it dries. It is very strong, so it is used as the base of buildings and bridges.

Gaining Heat

Other materials used in products and structures involve combining materials at high temperatures. To create shrink-wrap, heat is applied to plastic to make the material shrink. Glass is made from sand with small amounts of other ingredients, such as limestone and soda ash (sodium carbonate). When the sand mixture is heated in a hot furnace, it melts and changes into glass. The glass hardens as it cools.



Shrink-Wrap

Photo Credit: Itsanan / Shutterstock.com

How to Choose What to Use

Scientists often develop new materials that focus on a particular set of properties of an existing material that they are interested in changing. For example, a scientist may be interested in developing a flexible fabric that retains body heat when worn next to the skin. The fabric's flexibility is a mechanical property, and its ability to retain heat is a thermal property. A material that responds to its environment, is called a smart material. Smart clothes could control your body temperature, light up in the dark, or even keep themselves clean.

In developing new materials, engineers study existing materials at molecular levels to understand their chemical structures. These engineers often make small changes in an existing material and then run tests on these different forms. Engineers study the results of the tests to understand how changes in structure relate to changes in properties of a material.

Materials with a Purpose

Every material is useful for some purposes but not necessarily for others. To make a product with the properties that people want, scientists and engineers try to choose the most useful materials for the product. The cloth and stuffing of a pillow are soft materials. You would not want a pillow made of concrete or brick. You would also not want to ride a car or bicycle made from cloth.

- **Record three important facts from the text.**
- **Record two ideas that are new to you.**
- **Record one idea you would like to know more about.**



Activity 12

Record Evidence Like a Scientist



Quick Code: egs6119

Circle Back: Heat Transfer

Now that you have learned about interactions with heat, look again at Ironing. You first saw this in Wonder.

How can you describe Ironing now?

How is your explanation different from before?

Look at the Can You Explain? question. You first read this question at the beginning of the concept.



Can You Explain?

What happens to an object when heat is transferred?

Now you will use your new ideas about Ironing to defend a claim using evidence. First, write your claim. A claim is a one-sentence answer to the question you investigated. It answers, What can you conclude? It should not start with a *yes* or *no*.

Record your claim.

Next, write a scientific explanation with evidence that supports your claim. Evidence can come from videos, readings, interactives, and Hands-On Investigations.

Record your evidence-based scientific explanation.

Choose one additional idea that you would like to research. **What would you do to learn more? What resources would you use to extend your research? How would you build upon your investigations?**

Unit Project Connections: Heat Transfer

How does your deeper understanding of heat transfer connect with the Unit Project, Zeer Pot Cooling? What research and resources will you need to complete the Unit Project?

Life Skills **I can apply an idea in an innovative way.**



Solve Problems Like a Scientist

Quick Code: egs6146

Unit Project: Zeer Pot Cooling

In many parts of the world, people do not have the ability to store food for long periods of time.


Zeer Pot

The zeer pot is an electricity-free innovation that can keep food cool and fresh. It works by using evaporative cooling. As the water in a zeer pot evaporates due to thermal energy from the sun, the water takes heat from the inner pot, cooling the inside as well as the contents.

Imagine the chill you feel when you step out of a warm shower into a cool room. The water on your skin starts to evaporate. But to change into a gas, that water needs heat energy. It gets that heat energy from your skin. The water on your body cools down, and so do you.

The zeer pot is made from two clay pots, one smaller pot inside a larger pot, with the space between them filled with wet sand. A piece of cloth is soaked in water, wrung out, and placed on top of the zeer pot.

As water in the sand evaporates through the surface of the outer pot, heat is transferred away from the inner pot, thereby cooling the inside of the inner pot. Cooler air remains inside the pot.

When placed in a shaded, breezy location, water evaporates faster. A good breeze or a fan powered by a solar panel blowing on the pot can really reduce the temperature inside the inner pot. The wind causes evaporation by lifting away water molecules, which carries away heat.

The zeer pot has been tested with several different vegetables. Tests have shown that these foods can be kept fresh for the following amounts of time:

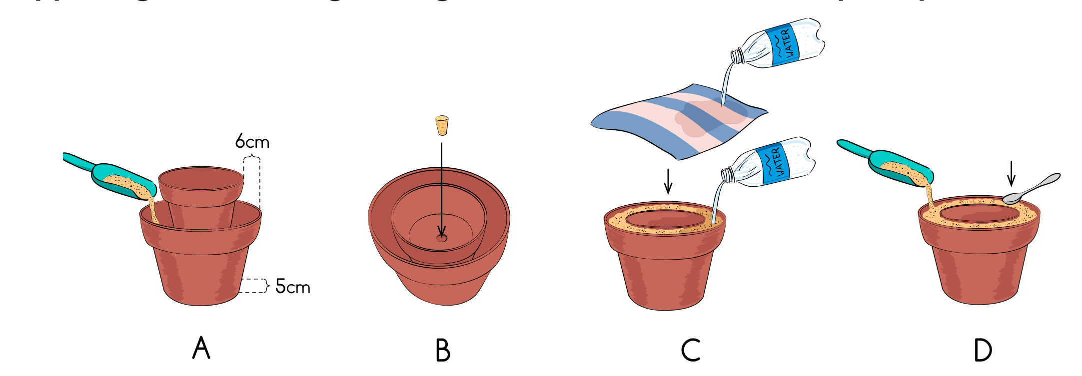
Vegetable	Time It Stays Fresh without a Zeer Pot	Time It Stays Fresh with a Zeer Pot
Tomatoes	2 days	20 days
Carrots	4 days	20 days
Okra	4 days	17 days
watercress	1 day	5 days

Life Skills **I can carry out solutions and evaluate results.**

Making a Zeer Pot

1. Get two unglazed ceramic pots—one that will fit inside the other with about 6 cm of space between the pots. Fill the bottom of the larger pot with about 5 cm of sand.
2. Put the smaller pot in the larger one. Cover the hole in the bottom of the pot with clay or a rubber stopper.
3. Fill the space between the pots with sand. Pack it down firmly.
4. Pour water into the sand and cover the pots with a wet cloth.

Place the images into the correct sequence to show how a zeer pot is made. Add labels to explain what is happening in each image and give details of the scientific principles in use.



Step 1 ___________

Step 2 ___________

Step 3 ___________

Step 4 ___________

Refrigerators and Zeer Pots

Compare a zeer pot to a typical refrigerator. What are the advantages and disadvantages for each?

Device	Advantages	Disadvantages
Refrigerator		
Zeer Pot		

Testing a Zeer Pot

What are some ways you can test what affects the temperature in a zeer pot? Choose one of the following questions and make a plan to test it. Write about the steps you would take in your investigation and provide a drawing of your plan.

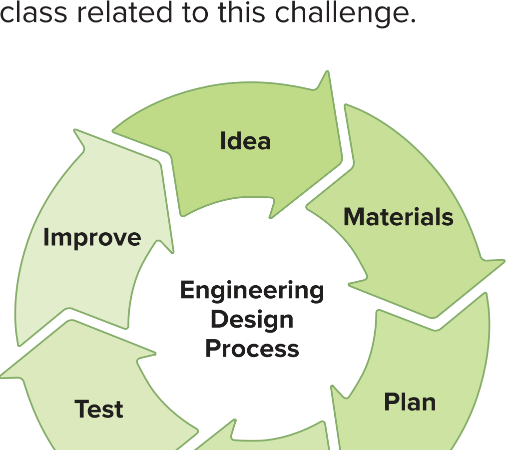
- **Does the size of the zeer pot affect the temperature?**
- **If the inner pot is glazed, will the drop in temperature be greater or smaller?**
- **Do different types of sand make a difference to the temperature?**



Interdisciplinary Project: Innovate for the Future

Quick Code: egs6148

In this interdisciplinary project, you will use your science and math skills to find a solution to a real-world problem. First, you will read a story about a fictional group of characters, called the STEM Solution Seekers. Then, you will study some background information, and you will design, test, and refine a solution to the overall challenge. You will go through the steps of the Engineering Design Process, as shown in the diagram. You will also do some additional work in your math class related to this challenge.



The project Innovate for the Future challenges you to think about ways the brain and a computer, or robotic device, think. In the story, you will read about a problem that the STEM Solution Seekers encounter while visiting a Japanese restaurant. You will consider ways to create a device that can help you complete your homework, as well as design and build a prototype of your device.

Homework Machine

Ali, Rania, Lamiaa, and Malek dream of building a homework machine!

The STEM Solution Seekers—Ali, Rania, Lamiaa, and Malek—are presenting a project at the Young Scientist Summit in Tokyo, Japan. While the projects are judged, they have lunch in a nearby restaurant.

A colorful robot shaped like a small human with flashing lights for eyes and a computer screen for a mouth scoots up to their table, and a voice says something in Japanese that they do not understand. It beeps and makes a whistling noise as if trying to get their attention.



"Uh oh, now what?" asks Rania. "I do not know enough Japanese for this." The robot's lights start flashing, and it buzzes as a lighted flashing arrow points to a list of languages on the screen. Lamiaa presses English since it is the only language they all share.

"May I take your order, please?" the robot asks almost immediately in its digitized English-language voice.

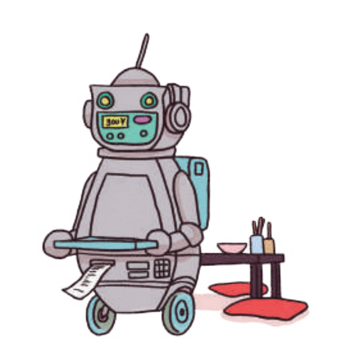
Surprised, the S3 team starts laughing, and Ali says, "I cannot believe it!"

The robot's stilted voice responds, "I-cannot-believe-it . . . is not on the menu. Do you need more time?"

"YES!" says Malek with a laugh, and they all watch in amusement as the robot beeps and moves to the next table where it opens a door in its stomach area and the diners take out their food. "There must be some kind of algorithm built in for when to go back to each table. I will bet I could program something like that."

Rania says, "I do not know how long that algorithm takes, but we had better look at the menu and figure out what we want. Who knows Japanese?"

The S3 team figures out the menu using the pictures, and when the robot returns, they order several dishes to share. "Thank you," says the robot voice. "Please enjoy some tea while our chefs prepare your . . . noodles, white rice, tuna sushi, vegetable sushi," the robot says, confirming their order. "Your food will be served in 17 minutes. Push the blue button on the table if you need anything while you wait."



They watch as the robot beeps, whirs, and flashes on its way to another table where it makes a ringing sound before it spits out a piece of paper with the group's bill.

“Wow,” Ali says. “Could you really write such a complicated program, Malek?”

Malek says, “It is probably not as complicated as you think, Ali. You just need to know all the variables and be able to input the correct code.”

“Malek, maybe we could make some kind of robot that could help us answer all the emails and posts to our website,” Lamiaa suggests.

“We have Rania for that,” Malek says, teasing her and making them all laugh.

Rania blushes for a moment at his affectionate attention and then says, “Seriously, Malek, could you make a robot that would do my homework?”

“Great idea!” Ali practically bursts with excitement. “I could invent some kind of body for it. It probably would not need to be as big as the one here.”

Lamiaa smiles and says, “Imagine how much time we could save with something like that! It would give me more time to work on my environmental projects even if it only did my math homework for me. I can work on building the circuits we need.”

“Math is easy,” Malek says. “We already have calculators for that. A robot would only need to have a way of inputting the math problem to solve it. It would be a real challenge to come up with something for the reading and writing assignments. If we could do that, we would be miracle workers!” Malek smiles broadly.

“Computers already have spelling and grammar check,” Rania points out. “How much harder would it be to compose sentences?”

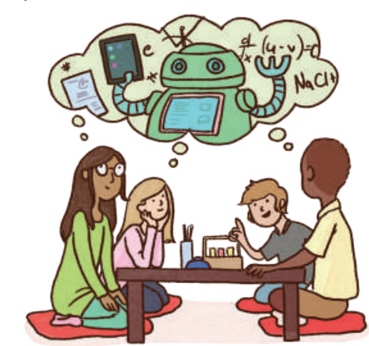
Ali says, “Do you know about Watson, the computer that went on a game show and answered all the questions and won? It was like he could think for himself. There are several computers out there with artificial intelligence. Can they write an essay? They operate like our brain.”

“I wonder if teachers would think that was some kind of cheating,” Lamiaa wonders.

Responding quickly, Rania says, “I will bet my teachers would not be happy with me if I told them a robot did my homework. Although, on second thought, maybe Ms. Salah, my science teacher, would like it. She is always encouraging us to come up with new ways to solve our problems.”

“What if you just gave it the assignment and told it what you wanted to say about it? Then all it would be doing is arranging the ideas you already had. Is that still cheating?” Ali asks.

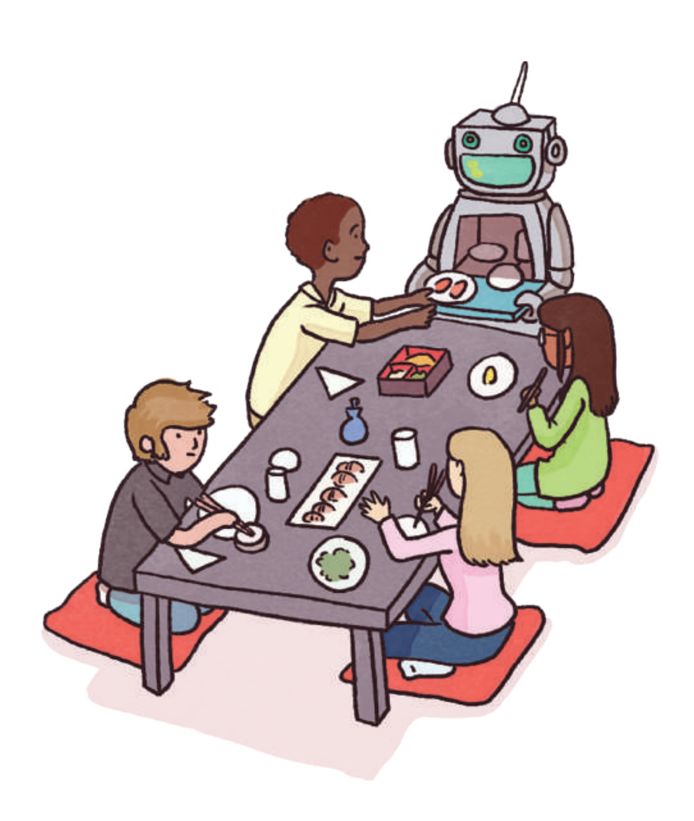
Malek has been thinking. “I don’t know, Ali. I think it would be fun to try, though.”



The robot returns to the table, and they take their plates from shelves in the robot's body.

"This is so cool," Rania says. "I think we need to invent a robot that can do our homework for us—all kinds of homework."

As they eat and talk, the S3 team decides that their next project will be a homework machine. When they return to the conference, they find that their project has won second prize. The winning groups are treated to a party with Japanese mochi and soda in a small room at the conference center. Before they have a chance to finish their celebration, Ali eagerly asks, "Okay, so when do we start on the robot?"



Artificial Intelligence

These are exciting times in artificial intelligence. Scientists have discovered many ways for artificial intelligence computers to help us.

Medicine

In medicine, doctors and hospitals use supercomputers to review individual health data. The vast amount of material available in public databases, textbooks, and journals helps them develop more personalized treatments. One important research area of artificial intelligence is the study of brain-computer interfacing. Brain-computer interfacing occurs when a device uses signals from the brain to control something, such as a cursor on a computer or controlling finger movement as part of a prosthetic limb.

Industry

In addition to medical applications, artificial intelligence is finding its way into jobs that are too dangerous for humans. Mining, nuclear power plants, and construction are some of the areas where robots are being developed. Think about other jobs robots might do that could help keep humans safe.

Agriculture

Artificial intelligence even affects our economy. Farmers are under increased pressure to produce more crops to feed more people. Robots are being developed to do complex tasks that have not been possible in the past. Farming robots can manipulate their environment by picking vegetables or fruits, applying pesticides in a localized manner, or planting seeds. Sensors on robotic arms can tell which berries are ripe and which are not based on the shape and size of the berry. Other precision physical systems can dispense water, seeds, fertilizer, and other resources that keep plants healthy through a web application, like a popular farming game.



Robot Used in Farming

Artificial intelligence, as you have seen, influences many aspects of society. Consider your own community. How has technology had an influence where you live? How do you think jobs in your area may be affected by the continued development of artificial intelligence?



Hands-On Investigation

Engineering Your Solution

Challenge

Would you like a robot to do your homework for you? You will have the opportunity to design your own homework machine. To accomplish this, you might want to think about what you struggle with when you do your homework. Since you want your device to be able to actually do homework and not just help you out, you should try to come up with many potential issues you might experience. As you create a homework machine, think about ways the homework machine could adapt to your learning. For instance, if you are trying to solve a math problem and you add instead of subtract, what might your machine do?

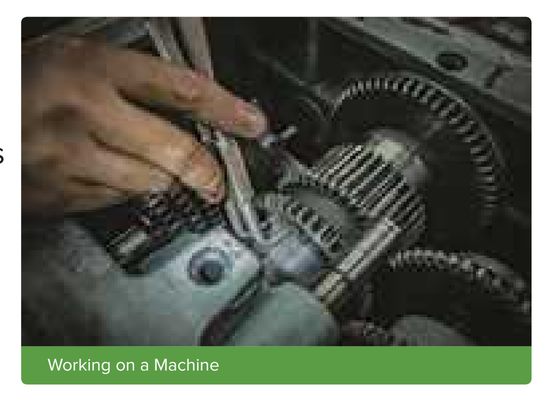
Constraints are limits. For this project, you will be designing the physical body of your proposed homework machine and identifying each part's function in detail. Two constraints are the materials and the time available that your teacher has provided for you. As you create the physical model, or prototype, of your homework machine, these are your additional constraints:

- Your prototype cannot exceed the following dimensions: 30 cm height, 30 cm width, and 30 cm depth.
- Your machine must include a way to identify what type of homework it is solving.
- Your prototype must be clearly labeled with each part of the machine and a description of what that part does.
- Use of technology is permitted, if available.

Objectives

In this engineering activity, you will

- create a list of components needed to create your design and a list of materials that will represent those components in the prototype
- build a prototype, documenting problems and solutions as you encounter them



Working on a Machine

Life Skills **I can choose the best solution to a problem.**

What materials do you need? (per group)

Building materials, such as boxes, tape, glue, string, or construction paper



Procedure

1. **Review the Challenge** Study the challenge and design requirements for this project.
2. **Assign Group Roles** Decide the roles for the members of your group and record the names next to each role.
3. **Sketch Ideas** Review the materials available with your teammates and begin brainstorming. Each team member should make their own sketch. Review your sketches as a group and decide on one design to fully develop. Add more details to make it your blueprint that you will use to help you create your solution.
4. **Plan and Build** With your teammates, gather materials and begin building your prototype. Make sure to keep track of your steps and process. Follow your group roles and work together. As you build, you will likely run into problems or challenges that you did not anticipate. Keep going. Solve one problem at a time, using your group's creativity to come up with solutions. Try multiple solutions to see what works best.
5. **Reflect and Present** Once your project is finished, reflect on your process and final product. Complete the Analysis and Conclusions section of your Student Investigation Sheet Identify ways you could improve. Prepare to share with your class.

Group Roles

Roles	Student Name
Team Captain Provide encouragement and support. Help other team members with their roles if needed. Keep track of timeline.	
Materials Manager Gather and organize materials. Request additional materials if needed. Adjust materials as needed (cut, size, fold, and so on).	
Engineer Coordinate building the model. Suggest when a test may be needed. Make sure the team is building safely.	
Reporter Record all steps of the process. Share the process the team went through to complete the challenge.	

Design Requirements

You will be applying your ideas and knowledge to design a solution for the challenge. The first step in the design process is to consider the purpose of what you will create and how your client will use it. In this case, you are the clients because the machine will be helping you do your homework!

You will tackle each of these tasks step-by-step through the following activities and prompts. For now, let's start with identifying your main goals. Here are a few questions to help you get started.
Check each box once you answer the question with your teammates.

- [ ] What type of homework will your machine solve?
- [ ] What does the machine need to do for this type of homework?
- [ ] Will it need speech, text, or image recognition?
- [ ] What decisions will your machine have to make?
- [ ] What materials would you use to build your machine?
- [ ] How would information travel from one part of the machine to another?
- [ ] What would the power source for the machine be?
- [ ] How will you know if the homework is done correctly?

Sketching Our Design

Scientists and engineers do not usually start out by building their design. Often, they sketch their ideas and then create a prototype, or model, that comes closer to the full product.

Sketching first saves resources, time, and money. Changes are much easier to make on paper or on a small-scale model than in full-size products.

You will begin designing your homework machine using sketches. As you work, be sure to record each change you make and why you are making it. Talk with your group and identify what remaining questions you have before you begin sketching. Do you need to explore the additional resources for more information? As you sketch, discuss what materials you want to use with your group.

With your team, discuss these two questions for your ideas:

- **What do you like about these ideas?**
- **Where can you make improvements to the design?**

Plan, Build, and Test

Follow these steps to complete the activity:

STEP 1 Now that you have selected one design idea, create a separate diagram with additional details that you will share during your presentation. This detailed diagram is the blueprint for your prototype. Identify any materials that you will use on the detailed diagram. Identify each major component needed for your homework machine (for example, a scanner to scan homework documents).

STEP 2 Gather the materials you identified in your blueprint. You may need to adjust these materials as you are building. Keep track of what you use. Ask your teacher what other materials you have available to use in your classroom.

STEP 3 With your teammates, begin building your project. As you build, you may run into problems or challenges. Focus on one problem at a time and use your group's creativity and collaboration skills to find solutions. Engineers use notebooks and documentation to troubleshoot when things go wrong so that they can look for places to make improvements.

STEP 4 Once your prototype is complete, work with your team to create a presentation to share both your prototype and your process. Share how you think this product will solve your homework problem. Also, prepare to share how your team worked together, if you encountered any problems, and how you worked to make improvements.

Optional Extension

Can you create circuits that show when the device is ready to start and when it is finished?

Presentation Notes

Analysis and Conclusions

1. **How could a homework machine help students all around the world?**
2. **What were a few of the most challenging problems you encountered? How did you solve those problems?**
3. **How is your prototype like your brain?**
4. **What are some of the benefits of using artificial intelligence? What are some of the risks?**

Excerise Unit 2

Question 1: Choose the correct answer

1. What is thermal energy?

A. The temperature of an object

B. The transfer of heat

C. Sum of the kinetic energy of the atoms and molecules in a substance

D. The mass of a substance

2. Heat will flow from the .... substance to the .... one..

A. hotter, colder　　**B.** frozen, melted

C. colder, hotter　　**D.** larger, smaller

3. The temperature of a substance is defined as the average amount of .... of the molecules or other particles of a sample of matter.

A. potential energy　　**B.** mass

C. kinetic energy　　**D.** number

4. Objects with more thermal energy have ....kinetic energy.

A. more　　**B.** less

C. the same　　**D.** no

5. .... happens as a result of the separation of the particles of a substance when heat is transferred to it.

A. contraction　　**B.** expansion

C. growth　　**D.** freezing point

6. If you want to design a product which conducts heat well, which material will you think of?........................

A. wood　　**B.** plastic

C. foam　　**D.** metal

7. .... is the transfer of heat due to the movement of a liquid or gas.

A. Radiation　　**B.** Conduction

C. Freezing　　**D.** Convection

8. What one of the following is an example of heat transfer by the radiation?

A. When the sun shines on your face, you feel warm.

B. When a pot of water is on the stove, it boils.

C. When a cake is in the oven, the hot air bakes it.

D. When you put a hot water bottle in the bed, it warms the sheets.

9. Raising the temperature of materials can cause ....

A. freezing and expansion

B. condensation and contraction

C. melting and expansion

D. melting and contraction

10. The point at which molecules in liquid water are heated and separated from each other until they become gas, is called ....

A. melting point

B. freezing point

C. boiling point

D. kinetic energy

11. Which energy is generated due to the motion of particles in a certain substance?

A. Thermal energy

B. Muscular energy

C. Momentary energy

D. Potential energy

12. Which of the following may not be a source of thermal energy?

A. Micro-oven

B. Sun

C. Moon

D. The heater

13. Heat is transferred by convection in the molecules of the following substances EXCEPT..................................

A. milk

B. water

C. atmosphere

D. iron

14. Sunlight and heat reach Earth by....................

A. conduction

B. radiation

C. convection

D. both convection and conduction

15. Matter in the liquid state has ....volume and ....shape.

A. fixed – fixed
B. variable - fixed
C. variable – variable
D. fixed - variable

16. .... is used to measure the temperature of materials.

A. Measuring container
B. Graduated cylinder
C. Thermometer
D. Measuring tape

Question 2: Put (√) in front of the correct statements and (x) in front of the incorrect ones.

1. Heat is transferred from a substance of low temperature to a substance of higher temperature. ( )
2. When the thermal energy of the objects increases, its kinetic energy increases too. ( )
3. Freezing is the transfer of heat due to the movement of a liquid or gaseous substance. ( )
4. Thermal energy transfer can occur in only two ways. ( )
5. Sunlight and heat reaching Earth is an example of thermal radiation. ( )
6. Matter in the liquid state has a fixed volume and a variable shape. ( )
7. Measuring container is used to measure the temperature of materials. ( )
8. The final temperature is greater than the temperature of two bodies in contact. ( )
9. Thermal energy is destroyed when it is transferred from one body to another. ( )
10. Thermal energy is transferred in metals by radiation. ( )
11. The transfer of heat between the two bodies stops when the temperature of each is the same. ( )

Safety in the Science Classroom

Following common safety practices is the first rule of any laboratory or field scientific investigation.

Dress for Safety

One of the most important steps in conducting a safe investigation is dressing appropriately.

- Use gloves to protect your hands and safety goggles to protect your eyes when handling chemicals, liquids, or organisms.
- Wear proper clothing and clothing protection. Tie back long hair, roll up long sleeves, and if they are available, wear a lab coat or apron over your clothes. Always wear close-toed shoes. During field investigations, wear long pants and long sleeves.

Be Prepared for Accidents

Even if you are practicing safe behavior during an investigation, accidents can happen. Learn the emergency equipment location if available and how to use it.

Most importantly, when an accident occurs, immediately alert your teacher and classmates. Do not try to keep the accident a secret or respond to it by yourself. Your teacher and classmates can help you.

Practice Safe Behavior

There are many ways to stay safe during a scientific investigation. You should always use safe and appropriate behavior before, during, and after your investigation.



Safety Goggles

- Read all of the steps of the procedure before beginning your investigation. Make sure you understand all the steps. Ask your teacher for help if you do not understand any part of the procedure.
- Gather all your materials and keep your workstation neat and organized. Label any chemicals you are using.
- During the investigation, be sure to follow the steps of the procedure exactly. Use only directions and materials that have been approved by your teacher.
- Eating and drinking are not allowed during an investigation. If asked to observe the odor of a substance, do so using the correct procedure known as wafting, in which you cup your hand over the container holding the substance and gently wave enough air toward your face to make sense of the smell.
- When performing investigations, stay focused on the steps of the procedure and your behavior during the investigation. During investigations, there are many materials and equipment that can cause injuries.
- Treat animals and plants with respect during an investigation.
- After the investigation is over, appropriately dispose of or store any materials that you have used. Ask your teacher if you are unsure of how to dispose of anything.
- Make sure that you have returned any extra materials and pieces of equipment to the correct storage space.
- Leave your workstation clean and neat. Wash your hands thoroughly.

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